A DESCRIPTION & USE OF A LARGE QUADRANT,

Contrived and made K

By H. SUTTON.

ACCOMODATED

With various LINES, for the eaſie Reſolving of All ASTRONOMICAL, GEOMETRICAL, and GNOMONICAL PROBLEMS, for working of Proportions, and for finding the Hour univerſally.

Whereunto is Added,

The Deſcription and Uſe of a GEODÆTICAL SCHEME, and GNOMONICAL INSTRUMENT: The firſt ſhewing (by Inſpection) the Dimenſions of All Geometrical Bodies: The other is applied to Gnomonical Uſes.

Publiſhed by R. MORDEN.

London, Printed by *W. Godbid* for *R. Morden* at the *Atlas* in *New Cheapſide* in *London*. 1669.

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OF A *QUADRANT* IN GENERAL.

A QUADRANT is the fourth part of a Circle, and is contained under two *right Lines* iſſuing from the *Centre* of the *Circle* (there making a right Angle) and of one fourth part of the *Circumference* of the ſame Circle: So that, a QUADRANT is bounded by three Lines, whereof two of them be *ſtraight Lines*, and are called the *Sides* of the QUADRANT; and the third is a *Crooked*, or *Circular Line*, called the *Limb*; and is alwayes (be the QUADRANT great or ſmall)

divided into 90 ſuch equal parts, as the whole Circle would contain 360 : and this Line thus divided, is called the *Equal Limb.*

Theſe three forementioned Lines, are the *limits* or *bounds* of a *Quadrant*; and that part of the *matter*, of which the Quadrant is made (be it *Silver, Braſs, Wood,* &c.) that is contained within theſe *bounds* or *limits*, is called the *Superficies of the Quadrant*; And upon this *Superficies*, is inſcribed ſeveral *Lines* for divers uſeful and neceſſary purpoſes in *Geometry*, and *Aſtronomy*, whoſe *Deſcription* and *Uſes* follow.

A General Deſcription of the ſeveral LINES *inſcribed upon this* QUADRANT, *and to what* Uſes *each of them may be made applicable.*

I. THe *Equal Limb* needeth no other Deſcription, than what hath

hath been already ſaid of it in the foregoing *Definition* of a Quadrant: That it is the fourth part of a Circle, divided into 90 Equal parts, which parts are called *Degrees*, and they are numbred by Arithmetical figures, from the left hand towards the right, by 10, 20, 30, *&c.* to 90 *Degrees*; Each of theſe Degrees is divided (or ſuppoſed ſo to be) into 60 other Equal parts, called *Minutes*; But in this *Quadrant* each *Degree* is divided only into four equal parts, each of which repreſenteth 15 Minutes, or one quarter of a Degree.

The chief uſe of this *Equal Limb*, is to take the *Altitude* of the *Sun*, *Moon* and *Stars*.

II. Upon the right ſide of the Quadrant, there is graduated a Line of *Natural Sines*, which Line iſſues from the Centre, and is divided into 90 unequal parts, alſo called Degrees; and theſe Degrees are numbred from the Centre downwards, towards the Limb (with

Arithmetical figures) by 10, 20, 30, *&c.* to 90 ; and back again, from the Limb upwards, towards the Centre, with ſmaller figures, by 10, 20, 30, *&c.* to 90, at the Centre ; and this Line, for diſtinction, hath the word *Sines* graven upon it.

By this Line, any of the *Caſes* of *Spherical Triangles*, which are reſolvable by *Sines* only, may be performed ; and ſo conſequently, many uſeful *Problems* in *Aſtronomy* (not only in one, but in all Latitudes) may be reſolved.

Verſed the 180 III. Upon the left ſide of the Quadrant, is graduated a Line of *Natural Verſed Sines*, drawn from the Centre of the Quadrant, which Line is divided into 180 unequal parts, and numbred with Arithmetical figures from the Centre downwards, towards the Limb, by 10, 20, 30, 40, *&c.* to 180 degrees, each of which degrees is ſuppoſed to be divided into 60 minutes ; but here they are divided only into ſo many parts as the

quantity,

quantity, or length of the Line will permit. It hath engraven upon it (for distinction sake) the words *Versed Sines*.

This Line principally serveth to resolve the fourth *Axiom* of *Spherical Trigonometry*, with great ease and exactness; and therefore may be made use of in finding the *Hour* of the Day, and the *Azimuth* of the Sun, at any time, and in any Latitude.

IV. On the outside of the Line of Sines, on the right edge of the Quadrant, there is another Line (not the full length of the side of the Quadrant) which is divided into 90 unequal parts, and numbred from the bottom upwards towards the Centre, by 10, 20, 30, *&c.* to 90 degrees, and those subdivided into minutes, according as the quantity will permit.

This Line, for distinction, hath engraven upon it the word *Latitudes*. Then,

V. Upon the left ſide of the Quadrant, without the Line, of Verſed Sines (but not iſſuing from the Centre) is deſcribed another Line, which is divided into ſix unequal parts, and numbred downwards, by 1.2.3.4.5.6. repreſenting *ſix Hours*, each of which Hours is ſubdivided (1.) into four unequal parts, repreſenting quarters of Hours, or 15 Minutes apiece; and each of theſe quarters is again (2.) ſubdivided into five ſmaller parts, each containing three Minutes. This Line is called the Line of ſix Hours, and, for diſtinction, hath the word *Hours* engraven upon it.

This Line of *ſix Hours*, together with the forementioned *Line of Latitudes*, will be uſeful in the Art of *Dyalling*; for by them moſt of the common ſorts of Dyals may be made in any Latitude.

These Lines hitherto deſcribed, are ſuch as are graduated upon the outermoſt bounds and limits of the Quadrant;

I ſhall

I ſhall now give you a Deſcription of thoſe that are inſcribed upon the *Superficies* of the Quadrant, beginning with thoſe next the *Equal Limb*, and ſo proceed upwards, till we come to thoſe next the Centre of the Quadrant: And thoſe are,

VI. A *Line of Hours*, numbred by 1.2.3.*&c.* to 12. from the right hand towards the left, and back again from the left hand towards the right, with the like numbers, each Hour being ſubdivided into its requiſite parts.

This Line hath upon it the word *Hours*, and unto it is adjoined *above*.

VII. A Line of *Verſed Sines*, divided into 180 unequal parts, and numbred from the right hand towards the left, by 10, 20, 30, *&c.* to 180 degrees, thoſe being again ſubdivided into Minutes, more or leſs, according as the largeneſs of the degrees will permit.

This Line of *Verſed Sines*, will find the *Hour* and *Azimuth* in the *Limb*;

and the *Line of Hours* is the degrees of the *Versed Sines* converted into *Time* for the more ready counting of the *Hour* without reduction, every 15 degrees of the *Versed Sine* containing one *Hour*.

VIII. Next above the Line of *Versed Sines*, is a Line of *Sines and Secants*, the *Sines* beginning at the right side of the Quadrant, and reacheth to 30 degrees of the Equal Limb counted from 90 backwards, that is, to 60 degrees: The *Line of Sines* is divided into 90 unequal degrees from the right hand towards the left, and then the *Secants* begin, and proceed forward, towards the left hand, being numbred by 10, 20, 30, &c. to 60 degrees.

IX. Above this Line (or Lines) of *Sines* and *Secants*, is a Line of *Tangents*, beginning at the right side of the Quadrant, and is numbred by 10, 20, 30, *&c.* towards the left hand, to 63 degrees, 26 minutes. This Line hath the

the word *Sines* graven at one end, and the word *Secants* at the other, to distinguish it from the rest.

These Lines of *Sines*, *Secants* and *Tangents*, are for the working of *Proportions* in the *Limb*, whereby several of the *Cases* in *Spherical Trigonometry* may be resolved.

X. Above these is inserted the *Geometrical Square* put into a Circle, and is here called the *Quadrat*. It is numbred from the left hand towards the right, by 1. 2. 3. &c. to 10, at 45 degrees of the *Limb*, where stands the figure 1 only, and from thence forwarder, towards the right hand, by 2. 3. 4. &c. to the right side of the Quadrant. It hath written upon it, for distinction sake, the word *Quadrat*.

This Line serveth chiefly to resolve some few *Cases* in *Plain Triangles* and principally such as are subservient to the finding of *Heights* and *Distances*.

These are the *proportional Lines* that are next to the *Equal Limb*, above these is a ſmall Margin, in which are ſet partly in *Numeral Letters*, and partly in *Arithmetical Figures*, certain Numbers ——and about three Inches, and $\frac{6}{10}$ above; there is another the like Margin figured partly with *Numeral Letters*, and partly with *Arithmetical Figures*, appropriate to ſeveral Lines drawn between theſe two Margins.

XI. The uppermoſt Line which boundeth the lower Margin, repreſenteth thoſe two ſmaller Circles of the Sphere, which are known by the name of the two *Tropicks*, *viz*. that of *Cancer* towards the *North Pole*, and that of *Capricorn* towards the *South Pole*. This one Line, I ſay, repreſenteth both theſe Circles; and,

XII. The undermoſt Circle, which boundeth the uppermoſt Margin, repreſenteth that great Circle of the Sphere,

Sphere, which is known by the name of the *Equinoctial*; neither of these Circles have any divisions upon them, but they are those representative Circles in the Sphere which bound the Suns course. And so there is,

XIII. Between these two Margins, delineated a *forced Projection of the Sphere*, being the same *Hour* and *Azimuth* Lines which Mr. *Gunter* describes in his *Quadrant*, printed in his Book of the *Sector*, *Cross-staff*, &c. The *Hour-Lines* are distinguished, so that they may be easily known by the Numeral Letters set to each Hour, as XII, XI, X, IX, VIII, VII, VI, in the upper Margin: And XII, I, II, III, IV, V, VI, VII, VIII, in the lower Margin, each Hour being divided into four parts, for *halves* and *quarters* of Hours. And the Azimuthal Lines may also be known by the Arithmetical Figures set to them both in the upper and lower Margins, namely, 10, 20, 30, &c. every fifth *Azimuth* being actually described

ſcribed, the intermediate ones muſt be eſtimated.

Croſs theſe *Hour* and *Azimuth* Lines from the *Equinoctial Circ'e* on the left hand, to the *Tropical Circle* on the right hand, is drawn,

XIV. An oblique Circular Line, divided into 90 parts or degrees, but not numbred, only it is charactred with the 12 Signs in this order:

♈	♍	♉	♌	♊	♋
♎....	♓	♏....	♒	♐....	♑.

The Characters of ♈ and ♎ ſtanding at the *Equinoctial Circle*, and ♋ and ♑ at the *Tropical Circ'e*, the other both as you ſee here (but better in the Quadrant it ſelf) depincted.

This Circle repreſenteth that great Circle in the Sphere called the *Ecliptick*; and it is that Circle in which the *Longitudes*, or *Places* of the *Sun*, *Moon* and *Planets* are accounted.

XV. There

XV. There is another Circular Line drawn croſs theſe *Hour-Lines* , from the point ♈ ♎,which Line is divided into 40 unequal parts called degrees, and numbred from the Equinoctial downwards, by 10, 20, 30, and 40, at the Tropick.

This Circle repreſenteth that Circle of the Sphere called the *Horizon* ; and its uſe, in this place, is to ſhew the Amplitude of the Suns Riſing or Setting, that is,how far diſtant the Sun(or other Star or Planet) riſeth or ſets from the true Eaſt or Weſt points, towards either North or South.

These are the Lines contained in this Projection,above which there is graduated,

XVI. A Line of the Suns Declination, divided unequally into 23 degrees and an half, and numbred by 10, 20, 23½, from the left hand towards the right.

This

This Circle ſheweth at any time of the year, how far the Sun is declined from the Equinoctial Circle, either Northward or Southward.

XVII. Above this Line (or rather Circle) of Declination in four concentrick Circles, are inſcribed the *Days of the year* in every reſpective Month, the four Circles repreſenting the four Seaſons of the year. The undermoſt Circle contains part of *March*, all *April*, *May*, and part of *June*.—— The next above the other part of *June*, all *July*, *Auguſt*, and part of *September*.——The third contains the remaining part of *September*, all *October*, *November*, and part of *December*. And in the laſt, is the other part of *December*, all *January*, *February*, and the former part of *March*.

The day of the Month being found in any of theſe Circles, is introductory to the reſolving of divers Spherical Problems, as hereafter will appear. Above theſe Circles of Months, there is,

XVIII. Laſtly,

XVIII. Laſtly, Certain Circles divided into *Hours*, and numbred backwards and forwards variouſly, and between them the names of certain fixed Stars placed againſt the proper Hours at which they come to be upon the Meridian at 12 a Clock at Night.

The uſe of thoſe Lines of Hours, and Circle of Stars, is to find the Hour of the Night by any of them.

Of each particular Line upon the Quadrant, *and its Uſe.*

UNto this *Quadrant* (as unto moſt others) there belongs a *Line* and *Plummet*, the *Plummet* may be either of *Braſs* or *Lead*, and the ſtring of ſmall well twiſted *Silk*, fixed at one end in the Centre of the *Quadrant*, and having the *Plummet* hanging at the other end, and upon it a ſmall *Bead* or *Pins head* (or two if you pleaſe) to ſlip up and down the ſame ſtring, and to

ſtay

ſtay fixed at any place upon the ſtring that you ſhall move it to.

The Quadrant being thus fitted, and you furniſhed with a pair of neat and ſmall Braſs Compaſſes, is ready to perform all the following *Concluſions*: Some whereof may be effected by the *Lines* upon the Quadrant by Inſpection only: Others, by help of the *Lines* and *Thrid* jointly. Some again, by help of the *Lines*, *Thrid* and *Bead* alſo: And ſome not without the help of *Compaſſes*.

Again, Some of the *Propoſitions* are peculiar to one *Latitude* or *Place* only; and others of them are *univerſal*, and ſerve in any part of the World.

Now the Names and Poſitions of the ſeveral Lines upon the Quadrant, together with their manner of numbring, and in general to what uſes they ſerve, I have already inſiſted upon: I will now branch them into particulars, ſhewing how to perform ſeveral Concluſions in Geometry, or Aſtronomy, by each of them. And herein I ſhall not obſerve

the

the ſame method as I did in their general deſcription; but begin with the *Uſes* of ſuch Lines firſt, as are moſt meet for the purpoſe intended in this *Tractate*; which is a gradual proceeding from the *Uſes* of one Line, to the *Uſes* of another, till I have paſſed over them all; in ſuch order, that a *primary Propoſition* ſhall not need a *ſubſequent* to be aſſiſtant to its reſolve; nor a *following Propoſition* be deficient, for want of any going before it. And ſo I will begin with the *Uſes*.

I. Of

I. Of the Lines (or Circles) of Months.

PROP. I.

Any day of the Year being given, to find what other day of the Year is of the same length therewith.

FInd the Month, and day of the Month in its respective Line or Circle, and that day of that Month which standeth against it in the other Circle thereto adjoining, shall be of the same length with the day given.

Example. Let it be required to find what day of the Year is of equal length with the 22 of *May*. Look the 22 of *May* in his proper Circle (which is that

that fartheſt from the Centre of the Quadrant) and againſt the 22 of *May*, in that Circle, you ſhall find in the Circle over it, the firſt day of *July* to ſtand, denoting, that the 22 of *May*, and the firſt of *July*, are dayes of equal length.

Again, Let it be required to find what day in the Year is of equal length with the 18 of *October*. Look for the 18 of *October* in the ſecond Circle of Months, and right againſt it, in the firſt Circle of Months, ſtands the ſecond of *February*, which is the day that is neareſt of length to the 18 of *October*.

PROP. 2.

What Night in the Year is equal in length with the firſt day of January.

LAy the Thrid upon the firſt day of *January* (which is in the uppermoſt

most Circle of Months) and in the third Circle, the Thred will lie over the fourth of *July*, and in the fourth Circle, over the 19*th* of *May*, either of which Nights are of equal length with the first day of *January*.

And in this manner you may find, that the 11*th* of *April*, and the 11*th* of *August*, are dayes of equal length; and that the nights of the sixth of *February*, and of the 14*th* of *October*, are also of equal length with those dayes.

II. Of

II. Of the Line (or Circle) of the Suns Declination.

PROP. 3.

The day of the Month being given, to find the Suns Declination.

BElow the four Circles of Months, is the Circle of of the Suns Declination, numbered from the left hand towards the right, into 23 degrees, 31 minutes.

Now to find the Suns Declination any day of the year—lay the Thrid to the day of the Month, and it will shew you in the Circle of the Suns Declination, what Declination the Sun hath

hath from the Equinoctial upon that day.

Example. Let it be required to find the Suns Declination upon the ſixth of *Auguſt*; Lay the Thrid upon the ſixth of *Auguſt*, and the Thrid will croſs the Line of Declination in 13 degrees, 43 minutes; and ſuch Declination hath the Sun upon the ſixth of *Auguſt*.

In like manner, the Thrid laid to

Janu. 7	The Thrid	20 d.	40 min.	S
Mar. 26	will cut the	6	19	N
June 23	Line of de-	23	1	N
Nov. 8	clination in	19	26	S

And ſuch degrees and minutes of Declination the Sun hath upon thoſe dayes.

But to know whether this Declination (thus found) be Northward or Southward from the Equinoctial, obſerve:

1. That if you find the day of the Month in either of the two uppermoſt Circles of Months, as here *January* and

and *November* were (for *January* was in the first Circle, and *November* in the second) then hath the Sun South Declination: But,

2. If you find the Month in either of the two undermost Circles, as here, *March* and *June* were (*June* being in the third Circle, and *March* in the fourth) then hath the Sun North Declination from the Equinoctial.

PROP. 4.

The Suns Declination being given, to find the day of the Month.

LAy the Thrid upon the degree and minute of the Suns Declination in the Circle of Declination, and then will the Thrid lie over four several dayes of the Year, upon either of which the Sun will have like Declination.

Example. Let the Declination given be 20 degrees. If you lay the Thrid

Thrid to 20 degrees in the Circle of Declination, it will croſs the Circles of Months upon the 10*th* of *January*, the 11*th* of *November*, the 9*th* of *May*, and the 14*th* of *July*; upon all which dayes, the Sun hath about 20 degrees of Declination, and which of thoſe dayes it is that you require, may be eaſily gueſſed by the time of the year; and whether the Declination be Northward or Southward, may be known by the Rule delivered in the foregoing Propoſitions.

III. Of the Ecliptick Line:

PROP. V.

The day of the Month being given, to find the Suns Place in the Ecliptick.

THe Ecliptick Line, is that which crosseth the Hour and Azimuth Lines of the *Projection*, and is divided and charactred with the 12 Signs of the *Zodiack*. Each space between Sign and Sign is divided into 30 unequal parts, and they are to be numbred both backwards and forwards, and therefore they have no Numbers set to them, but must be counted from Sign to Sign.

Example. Let it be required to find the Suns Place in the Ecliptick upon the

17*th* of *April*. The Thrid being applied to the 17*th* of *April*, will croſs the Ecliptick Line in 7 degrees, 41 min. of ♉, and in that Sign and degree of the Ecliptick is the Sun upon the 17*th* of *April*.

Again, upon the 21 of *November*, if it were required to find the Suns Place in the Ecliptick upon that day, the Thrid laid to the 21 of *November*, would croſs the Ecliptick Line in 9 degrees, 38 minutes of ♐; and in that Sign and degree is the Sun upon the 21 of *November*.

And here Note, That if you find your day of the Month in the undermoſt Circle of Months, the Sun is then in one of theſe three Signs, ♈, ♉, or ♊. But if in the next Circle above, it is then in ♋, ♌, or ♍. If in the next above that, it is in ♎, ♏, or ♐. And if in the upper Circle of Months, its Place is in ♑, ♒, or ♓. And by obſerving this order, you may account the degrees in the Ecliptick either

ther backward or forward, accor-
ding to the succession of the Signs.

PROP. 6.

The Suns Place in the Ecliptick being given, to find the Day of the Month.

LAy the Thrid to the Suns Place counted in the Ecliptick, and among the Circles of Months, it will lie upon the day required.

Example. Let the place of the Sun given be in 25 degrees, 32 minutes of ♌. The Third being laid thereto in the Ecliptick, will fall upon the eighth day of *August*, which is the day of the Month required.

Again, If the Sun had been in the 23 degr. 30 min. of ♒, the day of the Month would be found to be the first of *February*.

PROP. 7.

The Suns Declination being given, to find his Place in the Eclip-tick.

LAy the Thrid to the Suns Declination in its proper Circle, and it will cut the Ecliptick in that Sign and degree in which the Sun at that time is.

Example. Let the Sun have 14 degrees, 33 minutes of South declination, the Thrid laid thereto will cut the Ecliptick Line in 9 degrees of ♏, or 21 degrees of ♒; and in one of those two Signs is the Sun, when he hath 14 degrees, 33 minutes of South declination; and which of the two it is, may be easily judged by the time of the year.

PROP. 8.

The Place of the Sun in the Ecliptick being given, to find his Declination.

THE Thrid being laid to the Place of the Sun in the Ecliptick, will give the Suns declination in its proper Line or Circle.

Example. Let the Place of the Sun given be in 17 degrees of ♉, the Thrid laid thereto will cut the Line of declination in 16 degrees, 58 minutes; and such declination shall the Sun have when he is in the 17*th* degree of ♉, or the 13*th* degree of ♌.

PROP. 9.

The Place of the Sun in the Eclip-tick being given, to find the Suns Right Ascension.

LAy the Thrid to the Suns Place in the Ecliptick, and in the Equal Limb it will shew you the Right Ascension.

Example. Let the Suns Place be in the fourth degree of ♊, the Thrid laid to this point in the Ecliptick, will, in the Equal Limb of the Quadrant, cut *62* degrees, and that is the Suns Right Ascension when he is in four degrees of ♊.

But Note here, That if the Suns Place given be more than *90* degrees from the beginning of ♈, the Suns Right Ascension must then be more than

90

90 degrees. So that if the Sun were

in	♋ 26 d.	The Right	118
	♐ 4	Aſcenſion	242 deg.
	♑ 26	would be	298

and yet the Thrid laid to any of theſe points in the Ecliptick (which are all in the ſame point) yet the Right Aſcenſions of thoſe points muſt be counted as above ; for this Inſtrument being but a Quadrant, is capable of receiving no more than 90 degrees, either of the Ecliptick, nor of the Right Aſcenſion ; but the Right Aſcenſion muſt be accounted from the firſt point of ♈.

PROP. 10.

The Right Ascension of the Sun being given, to find his Place in the Ecliptick.

LAy the Thrid to the Place of the Suns Right Ascension in the equal Limb of the Quadrant, so shall it cut the Place of the Sun in the Ecliptick.

Thus the Thrid being laid to 62 degrees, will cut the Ecliptick in four degrees of ♊, which is the Suns Place, he having 62 degr. of Right Ascension; but this point of 62 degr. in the Limb,

may be accounted	118	Degr. of Right Ascension, and then the Suns place is in	26 d. ♋
	242		4 of ♐
	298		26 ♑

IV. Of

IV. Of the Horizon.

PROP. II.

The Place of the Sun in the Ecliptick being given, to find his Amplitude.

THe Suns Amplitude is the distance (counted upon the Horizon) that the Sun riseth from the true East or West points, towards either the North or South; and is alwayes North, when the Sun is in Northern Signs, as in ♈, ♉, ♊, ♋, ♌, or ♍. And Southward, when he is in Southern Signs, as in ♎, ♏, ♐, ♑, ♒, or ♓. To find this Amplitude,

Lay the Thrid to the Suns Place in the Ecliptick Line, then move the Bead

 which

which is upon the ſtring to the place of the Sun: The Bead being thus brought to the Ecliptick Line, is ſaid to be rectified; then move the ſtring along till the Bead touch the Horizon, and it will there ſhew you the Number of degrees of the Suns Amplitude.

Example. Let the Suns place be the fourth of ♊, lay the Thrid thereto in the Ecliptick Line, then bring the Bead to that part of the ſtring which croſſeth the Ecliptick Line; the Bead there reſting, move the ſtring along to the Horizon, and there you ſhall find the Bead to cut 35 degrees, 8 minutes; and ſo many degrees doth the Sun riſe from the true Eaſt point towards the North, and ſet ſo many degrees from the Weſt Northerly alſo, becauſe the Sun is in a Northern Sign.

But if the Suns place had been in the *26th* degree of ♑, the ſtring and Bead being brought to this point in the Ecliptick (which is the ſame point as before) then the ſtring and Bead being moved thence to the Horizon, will alſo

cut

eut 35 degrees, 8 minutes, as before, which is the Amplitude of the Suns Rising and Setting Southerly, because the Sun was in a Southern Sign.

In like manner, If the Amplitude were given, the Suns place might be found, by laying the Thrid, and bringing the Bead to the degrees of Amplitude in the Horizon, and from thence moving of the string to the Ecliptick, where the Bead will rest upon the Suns place, which you must judge by the time of the Year.

PROP. 12.

The Place of the Sun being given, to find the Ascensional Difference.

AS in the former Proposition, so in this, Let the Thrid be brought, and the Bead rectified to the Suns place

in

in the Ecliptick; so the Thrid being moved along, till the Bead touch the Horizon, the string will shew in the Equal Limb of the Quadrant, the degrees of the Ascensional Difference, which converted into time, is the quantity of time which the Sun riseth or setteth before or after the Hour of six.

Example. Let the place of the Sun given be the fourth degree of ♊, the Thrid being laid thereto, and the Bead brought to its due place, move the string till the Bead touch the Horizon; then will the Thrid in the Equal Limb of the Quadrant, fall upon 28 degr. 50 min. which is the Ascensional Difference required.

Now these degrees and minutes of Ascensional Difference, being turned into hours and minutes of time (which is done by allowing 15 degr. to one hour, and four minutes of time to each degree) will give you the distance of time that the Sun rises or sets before or after six a Clock ——

So theſe 28 degrees, 50 minutes converted into time, is one hour and 55 minutes: So that if the Sun be in a Northern Sign (as here it is) the Sun riſes one hour, 55 minutes before ſix, that is, five minutes after four of the clock; and ſets one hour, 55 minutes after 6, that is, at 55 minutes paſt 7.

But if it had been in Winter, and that the Sun had been in 4 degr. of ♐. then the Aſcenſional difference would have been the ſame as before, and then the Suns riſing would have been 1 hour 55 minutes after 6, that is, at 55 minutes after 7, and his ſetting at 5 minutes after 4.

And thus having attained the time of the Suns riſing and ſetting, the length of the Day and Night is eaſily known; for the time

$$\text{of}\begin{cases}\text{Sun Riſing}\\ \text{Sun Setting}\end{cases}\text{is the}\begin{cases}\text{Seminocturnal}\\ \text{Semidiurnal}\end{cases}\text{ark}$$

wherefore, the time of Sun riſing being doubled, giveth the length of the Night;

Night; and the Suns ſetting doubled, is the length of the day. Thus when the Aſcenſional difference in

$$\text{the}\left\{\begin{array}{l}\text{Summer is}\\ \text{Winter is}\end{array}\right\}\text{1 hour, 55 min.}$$

$$\begin{array}{r}\text{the length}\\ \text{of the}\end{array}\left\{\begin{array}{l}\text{Day}\\ \text{Night}\end{array}\right\}\text{will be}\left\{\begin{array}{ll}\text{15 h.} & \text{50 m.}\\ \text{8} & \text{10}\end{array}\right.$$

V. Of

V. Of the Equal Limb.

PROP. 13.

How to take (or make obſervation of) the Altitude of the Sun, Moon, or Stars.

FOr this purpoſe, upon the Right Edge of the Quadrant, are placed two Sights, made of Braſs, in either of which there is a ſmall hole for the Sun-beams to paſs through, or elſe to look thorough with your Eye to the Moon or Stars, or to the top of any Building, or the like, which you deſire to take the Altitude of.

To

To take the Suns Altitude, Hold up the Quadrant with both your hands, turning the left ſide of your body to the Sun, and with your hands raiſe up or depreſs the Quadrant, till the Sun ſhining through the hole of that Sight which is next the Centre of the Quadrant, caſt his beam of light upon the hole which is upon the other Sight fartheſt from the Centre, the Thrid and Plummet all the while having free liberty to play by the ſide of the Quadrant. Thus when the Sun ſhining through one Sight, caſts his beam of light upon the hole of the other Sight; at that time mark exactly what degrees and parts of a degree or minutes are cut by the Thrid on the Quadrants Limb, for thoſe degrees and minutes are the degrees of the Suns Altitude.

Thus to take the height of the Sun; but for the Moon,—Stars, or other objects, you muſt look through both the Sights to the object, and where the Thrid and Plummet reſteth, thoſe are

the degrees of Altitude —— But in theſe Caſes, if the holes of the Sights be too ſmall, you may then look by the edges of them, or by the edge of the Quadrant it ſelf; either of which ways being carefully performed, will do the thing intended.

VI. Of

VI. Of the Projection.

1. *Of the Hour-lines.*

THe Hour-lines in the *Projection* may be diſtinguiſhed from the reſt by their Numbers, and alſo by their ſcituation upon the Quadrant; for they are thoſe Lines which lie towards the left ſide of the Quadrant, and are numbred by Numeral Letters ſet at either end of each of them, in the two Margins before expreſſed; That Hour which hath XII and XII, at each end thereof, is the Hour-line of 12 a Clock; That which hath XI at the top or upper Margin, and I. at the bottom or lower Margin, is the Hour-line of 11 before Noon, or 1 Afternoon. So the next, which hath X at the top, and

II.

II. at the bottom, is the Hour-line of 10 in the Forenoon, and of 2 in the Afternoon, and ſo of all the reſt. Now between each Hour-line that is thus figured at both ends, there are three other Lines drawn, which have no Numbers ſet to them, and thoſe are the half and quarters of Hours. And further note, that of theſe Hour-lines there are two ſorts, one bending from the top, or upper Margin downwards, and incline towards the left hand; and theſe (for diſtinction) are called the *Winter Hour-lines*, and are in uſe only when the Sun is in Southern Signs. The other, bending downwards from the upper Margin, incline towards the Right hand, and are called the *Summer hours*, and are in uſe all the time that the Sun hath North Declination, or is in the Northern Signs. This diſtinction of the Lines being made, I will now ſhew the uſe of them.

PROP. 14.

PROP. 14.

The place of the Sun being given, to find what Altitude the Sun shall have at 12 a Clock.

LAy the Thrid to the place of the Sun in the Ecliptick, and rectifie the Bead, by bringing it to that part of the string; then move the Thrid along, till the Bead come to touch the Hour-line of 12, either in *Winter* or *Summer*; the Bead so resting, the Thrid will cut in the Equal Limb the degrees of the Suns Altitude at 12 a Clock.

Example. Let the place of the Sun be in the first degree or beginning of ♉ or ♍, lay the Thrid thereto, and bring the Bead to that point, then moving the Thrid along till the Bead comes to touch the Summer Hour-line of 12, the Thrid will then lie upon 50 degrees in the Equal Limb, and such Altitude will the

the Sun have at 12 a Clock when he is in the beginning of ♉ or ♍, which are points of the Ecliptick equally distant from ♈ or ♎, and so have like declination from the Equinoctial Northward.

Again, If you let the Bead still rest, and move the Thrid yet farther, till it touch the Summer Hour-line of 11 and 1, the Thrid will then cut 48 degrees, 12 minutes, and such Altitude will the Sun have at 11 or 1 of the Clock, when he is in the beginning of ♉ or ♍.

So at the Hours of	10	2	the Suns altitude will be	43 d.	12 m.
	9	3		36	00
	8 or	4		27	31
	7	5		18	18
	6	6		9	0

In like manner, the Sun being in the beginning of ♊ or ♌, the string laid thereto, and the Bead brought to that point, the string being moved to the Summer Hour-line of 12, will cut in the Equal Limb in 58 degrees, 42 minutes.

And the Bead being moved to the Hour-line of	11	1	The Thrid will cut in the Equal Limb.	56 d.	34 m.
	10	2		50	55
	9	3		43	6
	8 or	4		34	13
	7	5		14	56
	6	6		15	40
	5	7		6	50

And ſuch Altitudes ſhall the Sun have at theſe Hours, he being in the beginning of ♊ or ♌.

But on the contrary, If it were required to find the Suns Altitude at 12 a Clock, and ſo at any other Hour of the day, the Sun being in the firſt degree or beginning of ♏ or ♓. Then the ſtring being laid to that degree in the Ecliptick, and the Bead brought to that point, and then the Thrid removed till the Bead did come to touch the Winter Hour-line of 12, the Thrid would then cut in the Equal Limb of the Quadrant at 27 degrees, 1 minute, and ſuch Altitude would the Sun have at 12 a Clock.

And

And the ſtring being moved till the

Bead fell upon	11	1	Of the clock, the Altitude would be	25 d.	40 m.
	10	2		21	51
	9 or	3		15	58
	8	4		8	33
	7	5		0	6

And again, the Sun being in the beginning of ♐ or ♒, the ſtring laid, and the Bead rectified to that point, you ſhall

find the Suns altitude at		12	of the Clock to be	18 d.	18 m.
	11	1		17	6
	10 or	2		13	38
	9	3		8	12
	8	4		1	15

And ſuch Altitudes will the Sun have at thoſe Hours, he being in ſuch points of the Ecliptick; and whatſoever is ſaid of the firſt degrees of each Sign, the ſame is to be underſtood of the intermediate degrees.

PROP. 15.

PROP. 15.

The Day of the Month (or the place of the Sun in the Ecliptick) being given, to find the Hour of the Day at any time the Sun ſhining.

LAy the Thrid to the day of the Month, and where the Thrid croſſeth the Ecliptick Line, bring the Bead to that point (ſo is the Bead rectified to find the Hour any time that day) then holding up the Quadrant to the Sun, as you do to take his altitude, obſerve when the Sun ſhineth through the hole of one Sight, upon the hole of the other, then will the Bead (upon the ſtring) fall upon the true Hour of the day, and the degrees which the Thrid cuts in the Equal Limb, are the degrees of the Suns altitude at that time.

Example.

Example. Upon the 10*th* of *May*, the Sun being then about entring into ♊, lay the Thrid to the day of the Month, and it will cut the Ecliptick Line in the beginning of ♊, to which point bring the Bead, then if you, holding up the Quadrant to the Sun (the Plummet hanging at free liberty, and the Sun ſhining through the ſight, as is before preſcribed) ſhall find the Bead to reſt upon that Summer-hour that hath VIII at the top thereof, and IIII at the bottom thereof, you may conclude that it is either 4 of the Clock in the afternoon, or 8 of the Clock in the morning; and which of thoſe Hours it is, is eaſie to determine by the time of the day.——And at the ſame time that the Bead fell upon 4 or 8 of the Clock, the ſtring did cut 34 degrees, 13 minutes, and that was the altitude of the Sun at that time. And ſo if the Bead had fell upon that Hour that had been marked with IX and III, it had been 9 in the morning, or 3 in the afternoon. If upon the Hour marked

X and I I, it had been 10 in the morning, or 2 in the afternoon, and ſo of any other. And what is ſaid of the Summer-hours, the like is to be underſtood of the Winter-hours; and when the Bead falls upon any half, or quarter Hour-line, then it is half or quarter of an Hour paſt the Hour preceding; and for leſſer parts then quarters of Hours, you may well enough gueſs at them.

PROP. 16.

The Day of the Month, and the Altitude of the Sun being given, to find the Hour of the Day.

LAy the Thrid to the day of the Month, and bring the Bead to the Ecliptick Line, then laying the Thrid to the Suns altitude counted in the Equal Limb, the Bead amongſt the Hours ſhall ſhew you the Hour of the day.

Example.

Example. Upon the 10*th* of *April*, the Suns altitude is obſerved to be 40 degrees; Lay the Thrid to the 10*th* of *April*, and bring the Bead to that part of the ſtring which croſſeth the Eclip-tick, then remove the Thrid to 40 degrees in the Equal, ſo ſhall the Bead reſt upon the half Hour-line, which is between the Hour-lines of IX and III, and X and II; wherefore the Hour muſt be either half an Hour paſt 9 in the morning, or half an Hour paſt 2 in the afternoon.

PROP. 17.

The day of the Month, or the place of the Sun in the Ecliptick being given, to find the beginning and ending of Twy-light.

TWy-light is ſaid to begin, when the Sun is 18 degrees below the Horizon Eaſtward, and to end when

the Sun is descended below the Horizon Westward. Wherefore, lay the Thrid to the day of the Month, and rectifie the Bead, by bringing it to the Ecliptick Line; then bring the Thrid to 18 degrees in the Equal Limb, and the Bead shall shew among the Winter-hours (if the Question be in Summer, or among the Summer-hours, if the Question be in Winter) the time of Day-break, or the beginning of Twy-light.

Example. Upon the 10*th* of *April*, lay the Thrid to that day, and rectifie the Bead to the Ecliptick Line. Then move the Thrid to 18 degrees in the Equal Limb, so shall the Bead, among the Winter-hours (because the Question was in Summer) fall a little more than a quarter of an Hour before 3 in the morning, which is the time of Day-break upon the 10*th* of *April*.

2. *Of the Azimuth-lines.*

THe *Azimuth-lines* are drawn on the Projection towards the Right side of the Quadrant, as the Hour-lines were towards the Left hand; and they are numbered at either end, both in the upper and lower Margins with Arithmetical figures, by 10, 20, 30, *&c.* And of these Sines, there are two sorts, as there were of the Hours, namely, the *Winter Azimuths*, and the *Summer Azimuths*, and they have like use as the Hours had: For,

PROP. 18.

The day of the Month (or the place of the Sun in the Ecliptick) and the Suns Altitude being given, to find the Azimuth.

THe Suns Azimuth is the diſtance (counted upon the Horizon) that the Sun at any time is diſtant from the Meridian, or South point. To find which,

Lay the Thrid to the day of the Month, and bring the Bead to that part of the ſtring which croſſeth the Ecliptick, then move the Thrid to the Suns altitude, counted in the Equal Limb(the contrary way, namely, from the right hand towards the left, calling 80 degr. 10 degr. and 70 degr. 20 degr. and 60 degr. 30 degr. *&c.*) So ſhall the Bead, either among the *Winter* or *Summer*

Azi-

Azimuth-lines (according to the ſea-ſon of the Year) ſhew you the Suns azimuth, or his diſtance from the Meridian or South-point.

Example. Let the time given be the *9th* of *April*, at which time the Sun is about the beginning of ♉, and let the Suns altitude be 46 degr. 40 min. at which time let it be required to find the azimuth.

Lay the Thrid to the *9th* day of *April*, and rectifie the Bead to the Ecliptick Line, then (becauſe the Suns altitude was 46 degr. 40 min.) count 46 degr. 40 min. from 90 degr. backwards upon the Equal Limb, and laying the Thrid thereto, the Bead will reſt upon the 30 Azimuth-line, ſhewing that when the Sun hath 46 degr. 40 m. of altitude upon the *9th* of *April*, the Sun is then diſtant from the Meridian Eaſtward if it be in the forenoon, or Weſtward if in the afternoon 30 degr. from the South.

In like manner, the same day, if the

Suns altitude had been	43 d.	55 m.	The Suns azimuth from the Meridian would have been	40	degrees.
	40	11		50	
	35	23		60	
	29	27		70	
	21	29		80	
	14	25		90	
	6	45		100	

PROP. 19.

The day of the Month, and the Azimuth of the Sun being given, to find the Altitude of the Sun above the Horizon.

LAy the Thrid to the day of the Month, and bring the Bead to the Ecliptick Line, then move the Thrid till the Bead touch the given Azimuth, so shall the Thrid, upon the Equal Limb, give you the Suns altitude, it being counted from 90 degr. backwards.

Example.

Example. Let the time given be the *9th* of *April*, as before, and the azimuth 70 degrees from the Meridian, lay the Thrid to the day, and bring the Bead to the Ecliptick Line, then move the Thrid till the Bead touch the *70th.* Azimuth, then ſhall the Thrid upon the Equal Limb cut 29 degr. 27 min. (they being accounted backwards from 90) and ſuch altitude ſhall the Sun have when he is 70 degr. diſtant from the South-part of the Meridian upon the *9th* of *April.*

VII. Of the Proportional Lines upon the Sides of the Quadrant.

THe Proportional Lines upon the Quadrant are of two kinds, *viz.* *Straight* and *Circular*; the *Straight* ones are thoſe on the *Sides* of the *Quadrant*, and the *Circular* are thoſe that lie between the *Equal Limb*, and the *Projection*. And by theſe Lines may be performed ſuch Concluſions *Univerſally* in all *Latitudes*, which the *Projection* (whoſe Uſes are before taught) performeth only in one Latitude, namely, for that place for which it is made. *Examples* in each kind ſhall follow; and firſt I will begin with the Proportional Lines on the ſides of the Quadrant, which are,

1. *A Line of Natural Sines to 90 degrees.*

2. *A Line of Verſed Sines to 180 degrees.*

All Proportions (and conſequently all Aſtronomical Problems) in Sines alone may be wrought by the Line of Sines, and therefore I will begin with the uſe of that.

1. *Of the Line of Sines.*

PROP. 20.

The Suns diſtance from the neareſt Equinoctial point being given, to find his Declination.

THe points ♈ and ♎ are the two Equinoctial points, ſo that let the Sun

Sun be in any point of the Eclip-tick whatsoever, he can never be above 90 degrees distant from one or other of these points.

So the Sun being in the beginning

of { ♉ ♓ / ♊ .. ♒ } he is { 30 / 60 } degrees distant from ♈.

But the Sun being in the beginning

of { ♌ ♐ / ♍ ♏ } he is { 60 / 30 } degrees distant from ♎.

And when he is either in the beginning of ♋ or ♑, he is then 90 degrees distant from either, and that is his greatest remotion, and at those times he hath 23 degr. 31 min. of Declination; these things being known, the Proportion will be:

> *As the Sine of the Suns greatest declination 23 degr. 31 min. is to his greatest distance from any of the Equinoctial points 90 degrees.*

So

So is the Sine of the Suns present distance from the next Equinoctial point (suppose 30 degrees) to the Sine of his present declination.

To work this Proportion upon the Line of Sines, take in your Compasses out of your Line of Sines, the distance from the Centre of the Quadrant to 23 degr. 31 min. (the Suns greatest declination) with this distance, set one foot of the Compasses in 90 degr. (the Suns greatest remotion from either Equinoctial point) and bring the Thrid to touch the other foot of the Compasses; so that it being turned about, it may only touch the Thrid in one point only, which is the perpendicular or nearest distance; then keeping the Thrid fast there, by laying your finger upon it, set one foot of your Compasses in 30 degr. (which is the Suns distance given) and open the other foot, so that it being turned about may only touch the Thrid, as before.

So

So this distance of the Compasses being measured upon the Line of Sines, will reach from the Centre of the Quadrant to 11 degr. 31 min. and such declination shall the Sun have when he is 30 degr. distant from any of the Equinoctial points. Thus by working the former Proportion upon the Line of Sines according to this last direction,

			d.	m.
you shall find, that if the Sun be	10	Degr. distant from either of the Equinoctial points, his Declination will be found	3	35
	20		7	51
	30		11	31
	40		14	52
	50		17	48
	67		20	14
	70		22	2
	80		23	9
	90		23	32

PROP. 21.

PROP. 21.

The Latitude of the Place, and the Declination of the Sun given, to find the Amplitude.

THe Proportion is,

As the Co sine of the Latitude is to the Radius;
So is the Sine of the Suns declination to the Sine of the Amplitude.

So the Latitude being 40 degr. and the Declination 15 degr. the Amplitude will be found to be 19 degr. 45 min. For,

Out of your Line of Sines, take the distance from the Centre to 15 degr. the Declination, then setting one foot of that Extent in 50 degr. the Complement of the Latitude, bring the Thrid to the nearest distance; then keeping it fast

faſt there, ſet one foot in 90 degr. and open the other, that it may only touch the Thrid ; ſo ſhall this diſtance of the Compaſſes, reach from the beginning of the Line of Sines, to 19 degr. 45 min. which is the Suns Amplitude required.

PROP. 22.

The Amplitude and Declination of the Sun given, to find the Latitude.

THis is but the Converſe of the foregoing Propoſition, and the Proportion for the working of it is this :

As the Sine of the Declination is to the Sine of the Amplitude ;
So is the Radius (or Sine of 90 degr.) to the Co-ſine of the Latitude.

So

So the Declination being 15 degr. and the Amplitude 19 degr. 45 min. the Latitude will be found to be 40 degr. For,

Take the diſtance of 15 degr. the Declination, out of your Line of Sines, and ſet one foot in 19 degr. 45 min. the Amplitude, and bring the Thrid to touch the other point, then ſet one foot in 90 degr. and open the other till it juſtly touch the Thrid, then will that Extent of the Compaſſes reach from the beginning of the Line of Sines to 50 degr. which is the Complement of the Latitude required.

PROP. 23.

The Latitude of the Place, and the Declination of the Sun given, to find what Altitude the Sun ſhall have when he is due Eaſt or Weſt.

THe Proportion is,

As the Sine of the Latitude
is to the Sine of the Declination;
So is the Radius
to the Sine of the Altitude.

So the Latitude of the place being 40 degr. and the Suns Declination 15 degr. take 15 degr. the Declination, out of your Line of Sines, and ſetting one foot of that Extent upon 40 degr. the given Latitude, bringing the Thrid to touch the other point; and there keeping it, ſet one foot in 90 degr. and open the

the other till it touch the Thrid, so shall this distance of the Compasses reach from the beginning of the Line of Sines, to 23 degr. 45 min. and such altitude shall the Sun have when he is upon the East or West Points, or Azimuths.

PROP. 24.

The Latitude of the Place, and the Declination of the Sun being given, to find what Altitude the Sun shall have at the Hour of six.

THe Proportion for resolving this Proposition, is,

As the Radius (or Sine of 90 degr.)
is to the Sine of the Suns declinat.
So is the Sine of the Latitude
to the Sine of the Suns altit. at six.

Take

Take the Suns Declination 15 degr. out of your Line of Sines, and setting one foot of that Extent in 90 degr. bring the Thrid to touch the other foot, and keeping it there, set one foot of the Compasses in 40 degr. the given Latitude, and open the other, so that it only touch the Thrid; this last distance of the Compasses will reach upon the Line of Sines, from the beginning of it, to 9 degr. 35 m. and such altitude will the Sun have at six a Clock.

PROP. 25.

The Hour of the Day, the Suns Altitude, and the Suns Declination being given, to find the Suns Azimuth.

THe Proportion by which this Problem may be resolved, is this:

As the Co-ſine of the Altitude is to the Sine of the Hour;
So is the Co-ſine of the Declination to the Sine of the Azimuth.

So the Hour being 45 degrees from the Meridian, which is the Hour of 9 or 3. the Suns Altitude 44 degr. and the Suns Declination North 15 degr. If you take 45 degr. the Sine of the Hour, out of your Line of Sines, and ſet one foot of that diſtance in 46 degr. the Co-ſine of the Suns Altitude, and bring the ſtring to the neareſt diſtance, there keeping it faſt. If you ſet one foot in 75 degr. the Complement of the Suns Declination, and open the other ſo that it may only touch the Thrid, that diſtance, meaſured upon the Line of Sines, ſhall reach from the Centre to 72 degr. 7 min. which is the Suns Azimuth from the South part of the Meridian, which ſubſtracted from 90 degr. leaves 17 degr. 53 min. his Azimuth from the Eaſt or Weſt; or ſubſtracted from 180 degr. leaves 107 degr. 53 min. the Azimuth from the North-part of the Meridian.

2. Of

2. *Of the Line of Verſed Sines.*

THis Line ſheweth chiefly to reſolve ſuch Caſes in Spherical Trigonometry, as lie under the fourth *Axiom* ; and that is,

1. *When two Sides and an Angle comprehended by them is given, to find the third Side :* Or,
2. *When the three Sides of an Oblique angled Spherical Triangle are given, to find an Angle.*

Under theſe two Caſes, lie three uſeful and neceſſary Problems, which by this Line are reſolvable *Univerſally* in all *Latitudes* with great eaſe and exactneſs; and they are :

1. *To*

1. *To find the Suns Altitude at all Hours.*
2. *To find the Azimuth of the Sun.*
3. *To find the Hour of the Day.*

Of which orderly.

PROP. 26.

The Latitude of the Place, the Declination of the Sun, and the Hour of the day being given, to find the Suns Altitude at that Hour.

LEt the Latitude of the Place be 40 degr. the Suns Declination 15 degr. North, and the Hour 45 degr. from Noon, *viz.* 9 or 3 a Clock, and let it be required to find the Suns Altitude at that Hour.

To perform this by the Line of Versed Sines, you must find the Sun, and the difference of the Complement of the Suns

Suns Declination, and of the Latitude, in this manner:

Latitude	40d.00′	*Comple-*	50d. 00′
Declinat.	15 00	*ment*	75 00
		Sum	125 00
		Differ.	25 00

Being thus prepared, take in your Compasses the distance upon the Line of Versed Sines, between the Sum and Difference here found; that is, between 125 and 25, and with this Extent of the Compasses, set one foot at the end of the Line, or at 180 degr. and bring the Thrid to the other point, at nearest distance; then keeping the Thrid there, set one foot of the Compasses in 45 degr. the Angle of the Hour given, and take from thence the nearest distance to the Thrid; this done, set one foot of this Extent of the Compasses in 25 degrees (the Difference before found) and the other foot will reach to 46 degrees, the Complement of the Suns Altitude

Altitude required, ſo the Altitude is 44 degrees.

PROP. 27.

The Latitude of the Place, the Declination of the Sun, and the Altitude of the Sun being given, to find the Azimuth.

LEt the Latitude given be 40 degr. the Declination 15 degr. North, and the Altitude 44 degr. and let the Suns Azimuth be required.

To effect this by the Line of Verſed Sines, you muſt firſt find the Sun, and Difference of the Complement of the Suns Altitude, and the Complement of the Latitude in this manner:

Latitude	40 d. 00′	*Comple-*	50 d.	00′
Altitude	44 00	*ment*	46	00
		Sum	96	00
		Differ.	4	00

This done, take in your Compasses from the Line of Versed Sines, the distance between *96* degr. and 4 degr. (which are the Sum and Difference before found) with this distance of the Compasses, set one foot at 180, the end of the Versed Line, and bring the Thrid to the other point at nearest distance; then keeping the Thrid there, take with your Compasses out of the Versed Scale, the distance from 4, the Difference before found, to 15 the Suns Declination (counted from 90 towards the Centre, if it be North-declination (as in this Example it is) or towards the Limb, if South) and with this distance, set one foot of the Compasses upon the Versed Line, moving it along the same, till the other foot being turned about do only touch the Thrid; and where the Compass point resteth upon the Versed Scale, that is the Azimuth from the North-part of the Meridian, which here it will be found to do, at 109 degrees, 54 minutes; which substracted from 180 degrees, leaves 70 degrees,

degrees, 6 minutes, for the Azimuth from the South.

PROP. 28.

The Latitude of the Place, the Declination of the Sun, and the Altitude of the Sun given, to find the Hour of the Day.

LEt the Latitude be 40 degr. the Altitude 44 degr. and the Declination North 15 degr. as before, and let the Hour be required.

First find the Sum and Difference of the Complement of the Suns Declination, and the Complement of the Latitude, in this manner:

$$\left.\begin{matrix}\textit{Declination} & 15\\ \textit{Latitude} & 40\end{matrix}\right\}\ \textit{Complement}\ \left\{\begin{matrix}75\\ 50\end{matrix}\right.$$

Sum	125
Differ.	25

 This

This done, take in your Compasses from the Versed Scale, the distance between 125 and 25, and with this distance set one foot in 180 ded, and bring the Thrid to the nearest distance, and it there resting, take in your Compasses the distance between 25 the Difference, and 46 the Complement of the Suns Altitude, with this distance set one foot upon the Versed Line, moving it along the same, till the other foot, being turned about, do only touch the Thrid; and where the point so resteth, is the degrees of the Hour from the Meridian, which here will be found to be at 44 degr. 46 min. which turned into time (by allowing 15 degr. for 1 Hour, and 4 minutes for each degree) is 2 Hours, and 59 minutes: So that if it were before Noon, it would be one minute past 9 of the Clock; but if it were in the Afternoon, then it would want 1 minute of 3 of the Clock.

 VIII. Of

VIII. Of the Proportional Lines on the Limb of the Quadrant.

THe Proportional Lines on the Limb of the Quadrant are *Tangents*, *Secants*, and *Versed Sines*, and their use shall follow.

1. *Of the Line of Tangents.*

To work Proportions in Sines *and* Tangents *jointly.*

TO work Proportions in *Sines* and *Tangents*, you must make use of the Line of *Sines* from the

 Centre,

Centre, and the Line of *Tangents* on the Limb; and in the working of ſuch Proportions, there are two Varieties.

1. *If a Sine be ſought.*
2. *If a Tangent be ſought.*

1. If a Sine be ſought, lay the Thrid to the Tangent in the Limb, it being one of the middle terms, and from the Sine being the other middle term, take the neareſt diſtance to it; then lay the Thrid to the other Tangent in the Limb, it being the firſt term, and entering that Extent between the Line of Sines and the Thrid, you ſhall have your Sine required in the Line of Sines; as in the Propoſition following.

PROP. 29.

PROP. 29.

The Latitude of the Place, and the Declination of the Sun being given, to find the time when the Sun cometh to be due East or West.

THE general *Canon* for working of this Proportion is,

As the Tangent of the Latitude is to the Tangent of the Declination;
So is the Radius to the Sine of the Hour from 6 a Clock, that the Sun comes to be due East or West.

Let the Latitude given be 52 degr. 30 min. and the Suns Declination 11 degr. 30 min.

To work this by the Proportional Lines, lay the Thrid upon 11 degr. 30 min. of the Tangent Line upon the Limb, then from the Sine of 90 degr. in the Line of Sines, take the nearest distance to the Thrid, then move the Thrid, and lay it over 52 degr. 30 min. the Tangent of the Latitude, which is the first term; and with the former distance of the Compasses, set one foot upon the Line of Sines, moving it along the same, till the other foot touch the Thrid, so shall the Compass point rest at 9 degr. in the Line of Sines, and at that time will the Sun be upon the due East or West points; which 9 degr. converted into time, is 36 min. so that the Sun will be due East or West 36 min. before 6 a Clock, that is, at 24 min. after 5 h. And this is the manner of the Operation *when a Sine is sought:* But,

2. *When a Tangent is sought*, Lay he Thrid to the Tangent, being one of ie middle terms, and from the other middle term being a Sine, take the nearest

rest distance thereto; then set one foot of that Extent upon the Line of Sines at the first term, it being a Sine, and bring the Thrid to the other foot, at nearest distance, so shall the Thrid rest upon the Tangent required in the Limb, as in the Proposition following.

PROP. 30.

The Suns distance from either of the Equinoctial points, and his greatest Declination given, to find his Right Ascension.

THe Analogy or Proportion is,

As the Radius,
is to the Sine of the Suns greatest Declination;
So is the Tangent of his distance from the Equinoctial point,
to the Tangent of his Right Ascension.

To work this by the Proportional Lines, lay the Thrid to the Tangent of 30 degr. the Suns diſtance from the Equinoctial point, it being one of the middle terms; then ſetting one foot of the Compaſſes in the Sine of *66* degr. 30 min. the Complement of the Suns greateſt Declination, it being the other middle term, and take the neareſt diſtance to the Thrid; then ſetting one foot of this Extent in the Sine of 90 degr. being the firſt term, bring the Thrid to the neareſt diſtance, ſo ſhall the Thrid reſt upon the Tangent of 27 degr. 54 min. which is the Tangent ſought, and is the Suns Right Aſcenſion for the time given.

---

2 *Of the Line of Secants, on the Limb.*

THis Line conſidered ſingly is but of ſmall uſe, but joined with other

Lines

Lines it is of good uſe, it ſupplying the Tangents wanting, and in finding the Hour and Azimuth in the Limb, by help of the Verſed Sines and Hours thereto annexed.

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3. *Of the Line of Verſed Sines and Hour-Scale upon the Limb.*

THe principal Uſes of this Line, is to find the *Hour* and *Azimuth* in the *Limb* of the Quadrant *Univerſally*, as in the Propoſition following.

PROP. 31.

PROP. 31.

The Latitude of the Place, the Declination of the Sun, and the Altitude of the Sun given, to find the Hour.

EXample. In the Latitude of *London*, 51 degr. 32 min. the Declination North, 23 degr. 31 min. and the Suns Altitude 36 degr. 42 min. and let the Hour be required.

You must first get the Meridian Altitude of the Sun for the day proposed, which is done, by adding the Suns Declination if it be North, to the Complement of the Latitude; or by substracting it from the Co-latitude, if it be South, thus:

Suns Declinat.	23	31	*Compl.* 66	d.	29'
Compl. Latit.	38	28	*Lat.* 51		32
Merid. Altit.	61	59			
Altitude given	36	42			

Being

Being thus prepared, take in your Compasses out of the Line of Sines, the distance between the Meridian Altitude, and the Altitude given, that is, between 61 degr. 59 min. and 36 degr. 42 min. with this distance of your Compasses, set one foot in the Centre of the Quadrant, and turn the other downwards upon the Line of Sines; and keeping the foot of the Compasses there, lay the Thrid over the Secant of the Latitude 51 degr. 32 min. and take the nearest distance to the Thrid. With this distance, set one foot of the Compasses upon 66 degr. 29 min. (the Complement of the Suns Declination) in the Line of Sines, and bring the Thrid to the other point at nearest distance, so shall the Thrid rest upon the Versed Scale at 60 degr. or at the Hours of 4 and 8, shewing it is either 8 in the Forenoon, or 4 in the Afternoon.

In like manner, If the Latitude given were 40 degr. the Altitude 44 degr. and the Declination 15 degr. North, the Hour would be found to be 44 degr. 46 min.

46 min. or 1 min. paſt 9 in the Morning, or 1 min. ſhort of 3 in the Afternoon.

PROP. 32.

The Latitude of the Place, the Declination of the Sun, and the Hour of the Day given, to find the Suns Altitude.

LEt the Latitude be 51 degr. 32 min. the Declination 23 degr. 31 min. and the Hour 60 degr. or the Hours of 4 or 8 from the Meridian.

Lay the Thrid over the Hour in the Verſed Scale, then ſet one foot upon 66 degr. 29 min. the Complement of the Declination in the Line of *Sines*, and with the other take the neareſt diſtance to the Thrid; then lay the Thrid to the Secant of the Latitude, and ſetting one foot upon the Line of *Sines*, move it along the ſame, till the other, turned about,

about, do only touch the Thrid; and where the Compaſſes ſo reſt, take the diſtance from thence to the Centre of the Quadrant, then ſet one foot of this diſtance in 61 degr. 59 min. the Meridian Altitude; and turning the other upwards, it will fall upon 36 degr. 42 min. which is the Altitude that the Sun ſhall have at the Hours of 8 or 4.

And in the ſame manner, If the Latitude were 40 degr. the Declination 15 degr. North, and the Hour 44 degr. 46 min. the Suns Altitude would be found to be 44 degr.

PROP. 33.

PROP. 33.

The Latitude of the Place, the Declination of the Sun, and the Altitude given, to find the Azimuth.

EXample. In the Latitude of *London*, 51 degr. 32 min. the Suns Declination North 23 degr. 31 min. the Altitude 18 degr. 20 min.

You must first get the Difference between the Suns Altitude, and the Complement of the Latitude, in this manner:

Complement Latitude	38 d.	28 m.
Suns Altitude	18	20
Difference	20	08

This done, take 20 degr. 8 min. the Difference, thus found, out of the Line of Sines from the Centre; and setting one

one foot in the Sine of the Declination, 23 degr. 31 min. turn the other foot downwards upon the Line of Sines, and there reſt it ; then lay the Thrid over the Secant of the Latitude 51 degr. 32 min. and from the point where the Compaſſes reſted in the Line of Sines, take the neareſt diſtance to the Thrid. With this Extent of the Compaſſes, ſet one foot in *69* degr. 52 min. the Complement of the Suns Altitude, and bring the Thrid to the other point at neareſt diſtance ; ſo ſhall the Thrid lie over 105 degr. in the Verſed Line, and that is the Azimuth from the South part of the Meridian.

In like manner, If the Latitude were 40 degr. the Declination 15 degr. North, and the Altitude 44 degr. the Azimuth from the South would be found to be 70 degr. 6 min. as in a preceding Propoſition.

IX. Of

IX. Of the Quadrat for Altitudes, on the Limb of the Quadrant.

THis Circle or Line is chiefly for taking of *Altitudes*, and proportioning of Shadows to their Gnomons; and its uſe may appear in a few Propoſitions, which I will reduce to theſe following particulars.

[FIG. III.]

1. *To take an Altitude acceſſible at one Station.*

LET AB be the Wall of ſome Steeple, Tower, or the like, whoſe height you require; Take the Quadrant,

drant, and looking through the Sights thereof, go nearer or farther from the Tower, till you ſee the top thereof at A through the Sights, and alſo that the Thrid and Plummet at the ſame time fall juſt upon 45 degr. of the Limb of the Quadrant, or upon the Figure I. in the Quadrat; which being found, meaſure the diſtance from the place of your ſtanding, which let be at C, to the baſe or foot of the wall at B, for that diſtance ſhall be equal to the height of the wall above your eye.

Thus ſtanding at C, ſuppoſe you ſee the top of the Tower A through the Sights, and that at the ſame time you find the Thrid to fall upon I. in the Quadrat, or 45 degr. in the Equal Limb; then meaſuring the diſtance from C, the place of your ſtanding, to B the foot of the wall, you find it to contain 39 foot, and that is the height of the wall or Tower from S to A, to which if you add O C, Equal to S B, the height of your eye from the ground

5 foot,

5 foot, you have the whole height of the Tower A B 44 foot:

But if you remove farther in as to D, till the Thrid hang upon 2 in the Quadrat of Shadows, or 63 degr. 26 min. in the Limb, then shall the distance D B be 19 foot and a half, which is equal to half the height of the Tower; so that 19 and a half being doubled, and 5 foot for the height of your eye added, the sum is 44 foot, as before.

Again, If you should move so far back as to E, till the Thrid hang upon 5. or 500 (rather) of the Quadrat, or 26 degr. 34 min. in the Limb (which is the Complement of 63 degr. 26 min. the degrees answering to the Figure II. in the Quadrat of shadows) the distance E B being measured, would be found to be 83 foot, to which add 5 foot for the height of your eye, and the sum is 88 foot, the half whereof is 44 the height of the Tower, A B as before.

Again, If you should remove yet farther back to F, till the Thrid fall upon

on of the Quadrat, or 18 degr. 26 min. in the Limb (which is the Complement of 71 degr. 34 min. the degrees answering to the Figure III. in the Quadrat of shadows) the distance BF being measured, will be found to be 127 foot, to which add 5 foot for the height of your eye, and the sum is 132, which is three times the height of the Tower AB, for 132 being divided by 3, giveth in the Quotient 44 for the height AB as before.

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2. *Another Way.*

FRom the Foot or Base of the Wall at B, measure out 10, 100, or 1000 equal parts, as 100 Foot from B to G, then standing at G, and looking through the Sights to A, you shall find the Thrid to fall upon 39 parts in the Quadrat, which is the height AS, to which if you add 5 foot for the height

of

of your eye, you ſhall have 44 for the height of the Tower, as before.

3. *Of inacceſſible Heights.*

IF the Altitude you are to take, as A B, be inacceſſible, ſo that you cannot come to meaſure from the Foot or Baſe thereof, by reaſon of ſome Ditch, or other impediment between B and D, therefore take ſome further place where you may order your ſtanding ſo, as to make the Thrid to hang upon 45 degr. in the Limb, or 1 in the Quadrat, as at C; then go back (in a right Line) ſo far, till you cauſe the Thrid to hang upon 5 in the Quadrat, which it will do when you have removed from C to E, then meaſure the diſtance between C and E, and that diſtance (adding 5 foot for the height of your eye) ſhall be equal to the height A B.

And here Note, That what is ſaid of Heights, the like is to be underſtood of Diſtances; for if the Tower A B were ſuppoſed to lie flat, the ſeveral ſtations at C, D, E, F and G, would find the Diſtance A B in the ſame manner, only the degrees or parts of the Quadrat muſt be counted from the contrary ſide of the Quadrant.

X. Of

X. Of the Quadrants of the Suns and Stars Afcenfions, and of finding the Hour of the Night by any of the Stars therein placed.

BEtween the 4 Circles of Months, and the Centre of the Quadrant, are 4 other Concentrick Circles, that next the Circles of Months, is the Circle of the Suns Right Afcenfion in Hours and Minutes, it being divided only into 6 Hours, for each quarter of the Ecliptick; and fo is numbred backwards and forwards, to 12 Hours. In the next Circle above, are 5 Stars placed, each of them according to his Right Afcenfion in the Quadrant over head: As,

Arcturus

Arcturus	at	2 h. 00 m.	of Right Ascension.
Aldebaron		4 18	
Aquila		7 35	
Regulus		9 50	
Ala Pegasi		11 56	

To find the Hour of the Night by any of these Stars.

THese 5 Stars (besides their being placed in the Circle of Ascensions) are also placed among the Hour and Azimuth lines in the Projection, and by any of them you may find its Hour as if it were the Sun.

Example. Upon the 15*th* of *May*, seeing of *Arcturus*, I would know the Hour of the Night by him. First, Laying the Thrid to the day of the Month, I find in the Quadrant of Ascensions, that the Suns Right Ascension is 4 hours, 8 min. which note down; then lay the Thrid over the Star in the Projection, and to the Star bring the

Bead ; then holding up the Quadrant, look through the Sights till you ſee the Star, where if you find him in the Weſt, and his Altitude 52 degr. the Bead ſhall then reſt upon the Hour-line of 2 Afternoon, and that is the Stars Hour.

Now if (in the Quadrant of Aſcenſions, which is over the Stars names) you take in your Compaſſes the diſtance from the Star, to the Suns Right Aſcenſion, 4 hours, 8 min. and ſet that ſame diſtance, upon the ſame Scale of Aſcenſions, at 2, which is the Stars Hour obſerved, the other point of the Compaſſes will fall off of the Quadrant ; wherefore ſet one foot upon 2 Hours counted in the Hours in the upper Scale or Quadrant, and then the moveable point will fall upon 11 hou. 54 min. which is the Hour of the Night.

Another Example will make this more plain.

IF upon the *9th* of *July*, the Sun then having 7 hours, 55 min. of Right Aſcenſion, I ſhould ſee the Star *Aldebaran*, or the *Bulls Eye*; and ſetting the Bead to him, obſerve his Altitude to be about 12 degr. at which time the Bead falls upon the 6 a Clock Hour-line, and that is the Stars Hour.

Now repairing to the Quadrant of Aſcenſions, ſet one foot of the Compaſſes to the Star *Aldebaran*, and extend the other to 7 hours, 55 min. the Suns Right Aſcenſion, with this diſtance ſet on foot in 6, the Stars Hour obſerved, and the other point will reach to 2 hours, 23 min. and that is the Hour ſought.

The like is to be done for any of the other Stars, and when the Compasses Excur the Ascension Scale, count the Hour in the Scale above, and that will give the true Hour, as in the first of these Examples.

XI. Of

XI. Of the Dialling Scales upon the Sides of the Quadrant.

THe two Scales for this purpose, are:

1. A Line of *Latitudes* on the Right.	Side of the Quadrant.	
2. A Line of *Six hours* on the Left		

The use of them shall be illustrated by two or three Examples.

I. *How to draw an Horizontal Dial in any Latitude.*

[FIGURE I.]

First, Draw a right Line A D for the Hour-line of 12, then in that Line, assume any point at pleasure, as A, for the Centre of the Dial, through which point draw another right Line at B C at right Angles thereto, for the Hour-line of *6* and *6*, Morning and Evening.

Secondly, Out of the Line of Latitudes, take in your Compasses the distance from the beginning of the Line, to 51 degr. 32 min. the Latitude of the place

place for which you would make the Dial; and set one foot of that distance upon A, the Centre of the Dial, to B and C upon the 6 a Clock Line.

Thirdly, Take in your Compasses, the whole length of the Hour-scale, and setting one foot of that Extent in B, with the other make a small arch of a Circle, crossing the Meridian, or 12 a Clock Line in D; likewise place one foot of the same Extent in C, and cross the former arch in the Meridian Line in the point D also, and draw the right Lines BD and CD.

Fourthly, Take in your Compasses the distance from 3 in your Hour-scale, to the beginning thereof, and set that distance from D to 3, and from D to 9, upon the Lines D B and D C, and (if your work be true) the points 3 and 9 shall divide the two Lines B D and C D each into two equal parts.—— Also from the Hour 3 in the Scale of Hours, take the distance from 3 to 1,

and ſet that diſtance upon the Line BD, from 3 to 5, and from 3 to 1. and alſo the ſame diſtance upon the Line C D, from 9 to 7, and from 9 to 11.—Again, Take out of your Hour-ſcale the diſtance from 3 to 2, and ſet that diſtance upon the Line B D from 3 to 4, and from 3 to 2. Alſo ſet the ſame diſtance from 9 to 8, and from 9 to 10.

Laſtly, Lay a Ruler to the Centre A, and draw Lines through the points 1, 2, 3, 4, 5. and 11, 10, 9, 8, 7. ſo ſhall they be the true Hour-lines belonging to an Horizontal plain for the Latitude of 51 degr. 32 min.

And if you would have the half Hours, and quarters of Hours upon your Dial, you muſt take them alſo as you did the whole Hours out of your Scale of Hours, and prick them down in the Lines B D and C D, as you did the other.

Alſo, for the Hour-lines of 4 and 5 in the Morning, and 7 and 8 at Night, which are drawn above the Hour of 6, they are put on by extending the Hours of 7 and 8, and 4 and 5 below 6, quite through the Centre A, and they ſhall be the ſame Hours above 6, as the others were below 6.

II. *How*

II. *How to draw a direct South Dial in any Latitude.*

[FIGURE I.]

THere is no difference between drawing of the Hour-lines upon a South Dial, and an Horizontal Dial for the same Latitude, only this; whereas out of your Line of Latitudes you took the Latitude of the place, and set it from A to B and C, you must, for a South Dial, take the Complement of the Latitude out of the Scale of Latitudes, and set it from A to B and C; so in a South Dial for the Latitude of *London*, which is 51 degr. 32 min. you must

must take 38 degr. 28 min. the Complement thereof, and set that distance from A to B and C. The rest of the work is directly the same with the other Dial, without any variation at all; but in the South Dial you must put no Hours before 6 in the Morning, nor after 6 at Night, as in the Horizontal Dial you did.

Of the Stiles for these two Dials.

1. THe Stile for the Horizontal Dial, may be either a piece of Brass cut with an Angle equal to the Latitude of the place, *viz.* in this Example, to 51 degr. 32 min. and set upright upon the Meridian, or 12 a Clock Line; or it may be a Wyer bowed to that Angle, and set upon the Meridian Line, as the other was.

2. The

2. The Stile for the South Dial may be of the same matter as the Horizontal, only it must be elevated only to the Complement of the Latitude 38 degr. 28 min. as the other was to the Latitude, 51 degr. 32 min. it must stand upright upon the 12 a Clock Line, and must point downwards towards the South pole.

III. *How*

III. *How to draw an upright declining Dial in any Latitude.*

[FIGURE II.]

BEfore you can draw the Hour-lines upon any such Plain, three things must be first found, *viz.*

1. *The height of the Pole or Stile above the Plain.*
2. *The distance of the Substile from the Meridian.*
3. *The inclination of Meridians.*

1. For

1. For the height of the Pole or Stile above the Plain, this is the Proportion:

As the Sine of 90,
Is to the Co-sine of the Latitude;
So is the Co-sine of the Plains Declination,
To the Sine of the height of the Pole above the Plain.

This Propoſition is to be wrought by Sines alone, Examples whereof you have in the 20, 21, 22, 23 and 24 Propoſitions beforegoing; and thus in the Latitude of 51 degr. 32 min. by working this Proportion; a Plain declining 25 degr. from the Meridian, the height of the Pole or Stile will be found to be 34 degr. 19 min.

2. For the diſtance of the Subſtile from the Meridian, this is the Proportion:

As the Sine of 90,
Is to the Sine of the Declination;
So is the Co-tangent of the Latitude,
To the Tangent of the Substiles distance from the Meridian.

3. For the Inclination of Meridians, this is the Proportion:

As the Sine of the Latitude,
Is to the Sine of 90;
So is the Tangent of the Declination,
To the Tangent of the Inclination of Meridians.

These two last Proportions are in Sines and Tangents jointly, in either of which it is a Tangent that is sought, wherefore they are to be wrought according to the Directions of the 30 Proposition beforegoing; and so working thereby, according to these Proportions, you shall find the distance of the Substile from the Meridian to be 18 degr. 34 min. and the Inclination of Meridians to be 30 degr. 47 min.

These

These three Arks,

1. The Stiles height	34	19	being found.
2. Substiles dist. from 12	18	34	
3. Inclination of Merid.	30	47	

We will now proceed to the making of the Dial.

To

To draw the Hour-Lines upon an upright declining Plain.

F*Irst*, Draw a Right Line CH for the 12 a Clock Line, and in some convenient place thereof, as at C, assume a point for the Centre of the Dial.

Secondly, With 60 degr. of any Line of Chords upon the Centre C, describe an arch of a Circle, and therein set off 18 degr. 34 min. the distance of the Substile from the Meridian; and draw the Line CF at that Angle, for the Substilar Line, and through the Centre C, and perpendicular to CF, draw another Right Line, as BCA.

Thirdly,

Thirdly, Out of your Scale of Latitudes, take 34 degr. 19 min. and ſet that diſtance from C the Centre of your Dial, to B and A on each ſide thereof.

Fourthly, Take in your Compaſſes the whole length of the Line of Hours, and ſetting one foot of that Extent in A, with the other deſcribe a ſmall arch of a Circle, croſſing the Subſtilar Line in F; in like manner ſet one foot in B, and croſs the former arch alſo in F, and draw the Lines B F and A F.

Fifthly, Foraſmuch as the Angle of the Inclination of Meridians is 30 deg. 47 min. ſee how many Hours are contained therein, and you ſhall find two Hours, and three minutes of time; wherefore the Subſtile muſt ſtand three minutes of time after 10 of the Clock. Wherefore,

Sixthly,

Sixthly, Take out of your Scale of

Hours		And set that distance upon the Line B F from B to	And upon the Line A F, from F to
0 h.	3 m.	4	10
1	3	5	11
2	3	6	12
3	3	7	1
4	3	8	2
5	3	9	3

Lastly, If from the Centre C, and these points 5, 6, 7, 8 and 9 in the Line BF, and the points 10, 11, 12, 1, 2, 3, in

in the Line A F, you draw ſtreight Lines, they ſhall be the true Hour-lines belonging to ſuch an upright plain declining 25 degr. in the Latitude of 51 degr. 32 min.——For the Hour-lins of 4, which would not come on upon the Line F A, it muſt be drawn through the Centre from the point 4 in the Line B F, as in the Figure.

The Stile muſt ſtand over the Subſtile, making an Angle of 34 degr. 19 min. and ſo is your Dial finiſhed.

F I N I S.

THE DESCRIPTION and USE OF A Geodætical Scheme, AND Gnomonical Instrument.

The first

Sheweth (by Inspection) the SIDES, ANGLES, PROPORTIONS and DIMEMSIONS of all Figures and Bodies superficial, solid, regular and irregular; with other GEOMETRICAL Conclusions in GAUGING.

The other

Sheweth the use of several HOROLOGICAL SCHEMES & LINES for DIALLING, on the General SCHEME; and also the taking of the Height and Distance of any Object, by the Shadow or Angles, with other GNOMONICAL Uses.

By *F. P.* Παντεχνόφιλος.

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THE
DESCRIPTION and USE
OF A
Geodætical Scheme,
AND
Gnomonical Instrument.

The first

Sheweth (by Inspection) the Sides, [illegible] Proportions and [illegible] of all Figures and Bo[illegible] solid, regular and irreg[illegible] other Geometrical Operations in Gauging.

The other

Sheweth the use of several Horological Schemes & Lines for Dialling, on the General Scheme; and also the taking of the Height and Distance of any Object, by the Shadow or Angles, with other Gnomonical Uses.

By F. P. Παντεχνόφιλος.

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THE DESCRIPTION & USE OF THE *Geodætical Scheme.*

PART I.

MAgnitude (as the Subject of all Dimensions) is a continued quantity, whose parts are terminated by Puncts, Lines, or Superficies.

As Puncts	are the	Lines,	having	Longitude without Latitu.
So Lines	terms	Superficies,		Longitude and Latitude.
Superficies	of	Solid bodies,		Longit. Latit, and Altitude.

These, as they are demonstrated in our Scheme, are the proper Subjects of this former part of our Treatise, whose Conclusions follow.

Sect. I.

Of Lines and Lineal Extents.

To find the Extent of the Sides of any Equilateral Figure by the graduated Circle.

THe Periphery or Circumference of the Scheme being divided (as usual) in 360 degrees (or equal parts) doth circumscribe the Sides, and terminate the Extents of all Equilateral Figures, whose terms are had by

 divi-

dividing 360 (the parts of the Circle) by the number of the ſides of any ſuch Figure inſcribed within it.

Thus the Point aſſigned in the Zenith or Vertex of our Scheme, being protracted, or Lines from thence drawn to their reſpective degrees on the Limb, do give the true Extents of the ſides of the Figures they repreſent ; whereof

a Figure made of		Sides, doth contain		parts, which defcribeth a	
	3		120		Trigone [Triangle.
	4		90		Tetragone.
	5		72		Pentagone.
	6		60		Hexagone.
	7		$51\frac{3}{7}$		Heptagone.
	8		45		Octagone.
	9		40		Enneagone.
	10		36		Decagone.
	11		$32\frac{8}{11}$		Hendecagone.
	12		30		Dodecagone.

The denominations of theſe Lines are expreſſed by proper Characters, with their numbers in the arches of the little Circle, through which they are drawn.

Alſo theſe Lines do repreſent the ſeveral Aſpects or Radiations of the Planets, according to the degrees of the Zodiack, diſtinguiſhed by their Characters.

viz.

Conjunction		80		☌
Opposition		180		☍
Trine		120		△
Quartile		90		□
Quintile		72		
Sextile	When a Pla-	60	Degrees of the Zo-	✱
Octile	net is removed	45	diack, whose proper	✱ ½
Decile	from another	36	Character is	
Semisextile		30		⊥ 1½
Sesquintile		108		
Triochle		135		✱ 3
Biquintile		144		✱ 2
Quincunx		150		⊥ 5

Note,

Note, That the prick't Lines drawn from the common angular point, are proper to the Aſpects; the other Lines are common to the Aſpects and Sides of the Geometrical Figures which they repreſent.

To find the Extent of the Sides of any Equilateral Figure by Geometrical Extraction.

THeſe Extents thus found by a Circular proportion on the degrees in the Limb, are Geometrically inſcribed within the leſſer Circle contiguous with the Sides of the Triangle; which being biſected in the Centre by two Diameters, the upper Semicircle with its Diameter, doth comprehend the Sides, *viz.*

of a	Trigone	by the Extent of the Line.	3	drawn from the	Dist. of the R. on each side the vert. to the limb.
	Tetragone		4		Distance of the vertical and horizontal points.
	Pentagone		5		Term of 7 through the vertex to the Horizon.
	Hexagone		6		Centre to the Circumference of the Circle.
	Heptagone		7		$\frac{1}{2}$ of the Line 3 laid parallel to the perpendic.
	Octagone		8		Horiz. point to the intersect. of C on the circle.
	Enneagone		9		Term of 3 on the circle, to $\frac{1}{3}$ of the semicircle.
	Decagone		10		Centre to the intersection of 5 on the Horiz.
	Dodecagone		12		Horizontal point to the Line 3 in the Circle.

SECT. 2.

Of Superficial Dimensions.

To find the Area or Superficial Dimensions of Æquilateral Figures.

The

The Side	3, 4	noted within	× $\frac{1}{2}$ ... ×--1	sheweth, that if you	Multipl. the base by $\frac{1}{2}$ the perp. or the perpendic. by $\frac{1}{2}$ the base. Multiply the base by the perp. or the perpendic. by the base.	The Product gives the Area of the superficies.
	5, 6, 7, 8, 9, 10, 11, 12	noted with	×Ↄr	sheweth, that if you	Multiply the sum of $\frac{1}{2}$ the sides by the Extent of the *Radius*.	

By

By the Extent of the Radius, you are to understand a Line falling perpendicularly, from the Centre at the base of the Figure, to one of the Sides: Therefore,

To find the Centre of a Regular Figure.

A right line drawn from the	side or angle	to its opposite	side & angle	& bisected, gives the Centre.

To find the Area, or Superficial Dimensions of Circular Figures.

The Dimensions of Circular Figures, do properly depend on this proportion.

as $\left\{\begin{matrix}7\\22\end{matrix}\right\}$ to $\left\{\begin{matrix}22\\7\end{matrix}\right\}$ so $\left\{\begin{matrix}\text{the Diameter}\\\text{the Circumference}\end{matrix}\right\}$ to $\left\{\begin{matrix}\text{the Circumference}\\\text{the Diameter}\end{matrix}\right\}$ of a Circle.

Wherefore,

the characters		representing		the symboles		shew, that if you	
	⊕		Circle		×rↃ		× the R. by $\frac{1}{2}$ cir.
	Ↄ		Semicircle		×r∋		× the R. by $\frac{1}{4}$ cir.
	⊖		Quadrant		×r⊖		× the R. by $\frac{1}{8}$ cir.
	◡		Arch, &c.		×rʃ		× the R. by $\frac{1}{2}$ ar.

fac: area.

Thus much touching the Superficial Dimensions of Regular Figures, either Right-lined, or Circular: Next, of Irregular Figures.

Sect. 3.

Of Irregular Figures.

To find the Area, or Superficial Dimensions of Irregular Right-lined Figures.

IRregular Right-lined Figures, are such whose Sides or Angles are unequal, according to which they have their Denominations, and are distinguished by

Triangular,

Triangular, or Trilateral.	Isocheles	having	2 of the sides unequal.
	Scalena		the three sides unequal.
	Orthygone		1 right, and 2 acute angles.
	Ambligone		1 obtuse, and 2 acute angles.
	Oxygone		3 acute angles.
Quadrangular, or Quadrilateral.	Parallelogram	having	equal opposite sides, & rectan.
	Rhombus		equal sides, & unequal angles.
	Rhomboides		unequ. sides & angl. oppos. equ.
	Trapezia		all other quadrilateral forms.
Multangular, or Multilateral.	Polygone	having	many Angles, many Sides unequal.

The Area or Superficial Contents of theſe Triangular Figures, are found as the Rectangular ; the reſt may be reduced into Triangles, by Diagonal Lines protracted from the angular points, and a perpendicular let fall from an angle to the baſe: Alſo the Rhombus and Rhomboiedes may be found by multiplying one ſide with the perpendicular let fall from the oppoſite ſide, as in a Rectangle Quadrangle.

Sect. 4.

Of Solid Dimensions.

To find the Area, or Cubick Dimension of Solid Bodies.

SOlid bodies are ſuch as are capable of the three dimenſions of magnitude, *viz.* length, breadth, and profundity; theſe are properly diſtinguiſhed by the forms they receive, whereof ſome are termed Regular, whoſe ſides, angles and baſes are equal and alike, the reſt are termed unequal. Theſe are expreſſed by proper Characters in our Scheme, as following.

viz.

P	denoteth a	Prisme	which containeth	angular basis, and æquiterminant sides.
⊙		Cylindre		circular basis, and parallel altitude.
P		Pyramis		angular basis, equidist. from the vertex.
C		Cone		circular basis, equidist. from the vertex.
T		Tetraëdron		4, bases & 4, solid angles — these are distinguished by the five Regular, or Platonick bodies.
H		Hexaëdron		6, bases & 8, solid angles
O		Octaëdron		8, bases & 6, solid angles
D		Dodecaëdron		12, bas. & 20, solid angl.
I		Icosaëdron		20, bas. & 12, solid angl.
⊙		Spheare		a solid fig. everywh. equidist. from the Centre.

Note

P	× ↄ r. 1	shew, if that you multiply	$\frac{1}{2}$ the periph. by rad. & prod. by the alt.
☉	× B 1		the basis by the altitude.
P	× B $\frac{1}{3}$		the basis by $\frac{1}{3}$ of the altitude.
C	× B $\frac{1}{3}$		the basis by $\frac{1}{3}$ of the altitude.
T	× B $\frac{1}{3}$		the basis by $\frac{1}{3}$ of the altitude.
H	× B 1		the basis by the altitude.
O	× B. 3		the basis in it self, product by 3.
D	× T. 12		the basis in it self, product by 12.
I	× T. 20		the basis in it self, product by 20.
⊕	× d. 11. ÷ 21		the diam. the prod. by 11 div. prod. by 21.

The solid contents of the figure is had.

Note, that the dimensions of Sphere, and consequently every spherical body, doth depend on the proportion of a Circle, and its Diameter, from whence the Superficies of a Sphere being known, the solidity thereof may be found from various proportions, *viz.*

In a Circle.

As $\left\{\begin{matrix}22\\11\end{matrix}\right\}$ to $\left\{\begin{matrix}7\\14\end{matrix}\right\}$ so the quadrat of the $\left\{\begin{matrix}\text{Semiphery}\\\text{Quadrat}\end{matrix}\right\}$ to the Circle.

In a Convex Superficies.

As $\left\{\begin{matrix}1\\7\\22\\11\end{matrix}\right\}$ to $\left\{\begin{matrix}4\\22\\7\\14\end{matrix}\right\}$ so $\left\{\begin{matrix}\text{the area or content of the circle}\\\text{the quadrat of the diameter}\\\text{the quadrat of the periphery}\\\text{the quadrat of the semiperiph.}\end{matrix}\right\}$ to the sphere.

Whence it follows; That if the area of a Circle be quadrupled, the product number will give the Convex Superficies of the Sphere.

In

In a solid Sphere.

As $\left\{\begin{array}{c}21\\363\end{array}\right\}$ to $\left\{\begin{array}{c}11\\49\end{array}\right\}$ so the Cube of the $\left\{\begin{array}{l}\text{Diameter}\\\text{Semiporiphery}\end{array}\right\}$ to the sphere.

The reason of the former proportion is plainly thus, that if the Diameter of the Sphere, the Cube of the Diameter will be 343, the Solidity of the Sphere $179\frac{2}{3}$. multiply both numbers by 3, the Factus will be 1029, and 529, which divide by 49, the quotient will be 21, and 11.

To

To find the Solidity of a Sphere by various Analogies.

viz. 1, 2, 3, 4, 5, 6, 7, 8 — Multiply

1. the semidiameter by $\frac{1}{3}$ of the convex superficies.
2. $\frac{2}{3}$ of the diameter by the area of the great circle.
3. $\frac{2}{3}$ of the area of the great circle by the diameter.
4. the semidiam. by 4 parts of the area of the gr.circle.
5. $\frac{1}{2}$ of the area of the gr.circle by 4 thirds of the diam.
6. the diam.doubled by $\frac{1}{3}$ of the area of the great circle.
7. the diamet.by $\frac{1}{6}$ part of the superficies of the Sphere.
8. $\frac{1}{3}$ of the diam by $\frac{1}{2}$ of the convex superfic.of the sphere.

The Analogy of a Cube and Sphere.

The area of a {Cube / Sphere} is found by multiply-ing a sixth part of the {Base / Sphere} by the {Side. / Diameter.}

Therefore, as 21 to 11, so is the Cube of the diameter to the Sphere.

Suppose

Suppoſe a Bullet whoſe Diameter is 24, this multiplied in it ſelf, *fac*. 576. the half is 288. whoſe root is 17, half of Diameter is 12, multiplied by 24, *fac*. 288. which multiplied by the root 17, *fac*. 4896, for the area of the Bullet. Otherwiſe

Cube the Diameter, multiply the ſame by 11, divide the product by 21, the quotient gives the ſolidity of the Sphere.

SECT.

Sect. 5.

Of the Segments of a Sphere.

To find the Superficies of an Hemisphere.

FOrasmuch as the Segments, or solid portions of a Sphere do depend on the superficial dimensions of the same; therefore to find the convex superficies of a Sphere excluding the Base, I shall propose these two varieties, *viz*, either

Multiply the { Semidiameter / Diameter } by the { Circumference / Semicircumfer. } of the great Circle.

To find the ſolid Segments of a Sphere.

Multiply the Semidiameter by { $\frac{1}{3}$ / $\frac{1}{6}$ } of the ſuper-ficies of the { Hemiſphere. / whole Sphere.

To find the Solidity of a Section of a Sphere.

Mul-tiply the { convex ſuperficies of the portion of the Sphere by { $\frac{1}{3}$ / $\frac{1}{6}$ } of the { Semidiameter. / Diameter.
Semidiam. by $\frac{1}{3}$ of the convex ſuperfic. of the por. of the ſphere. }

To find the Solidity of any portion of a Sphere.

First conſider, whether the portion propoſed be leſſer, or greater than an Hemiſphere.

If leſſer, then ſubſtract a Cone having the ſame baſe with the portion from the ſolidity of the Section, the remainder gives the ſolid contents of the leſſer portion.

If greater, then add the ſame Cone to the Section, the ſum gives the ſolid contents of the greater portion.

Sect. 6.

Of Decurted Bodies.

BY Decurted Bodies, we are to underſtand ſuch as are defective in their forms, whoſe irregularities are

diſcovered by the dimenſions of ſuch regular Figures from which theſe are decurted;

whence they are commonly diſtinguiſhed by { *Fruſtra Pyramidis.*
Fruſtra Coni.
Fruſtra Cylindri.

Therefore to find out the ſolid contents of ſuch bodies, you muſt continue their ſides to a regular *Pyramis*, *Cone*, or *Cylindre*, whoſe dimenſions being had by our former Rules, and ſubſtract the *Minor* from the *Major*, the remainder gives their reſpective Area, or Solidity.

Of GAUGING.

To find out the Capacity of a Vessel.

THE Capacity or Contents of a Vessel doth properly depend on the dimension of these decurted bodies, our common Vessels being no other than decurted Cylindres, as the same is demonstrated in our Scheme. To find the Capacity of which, two things are requisite, *viz.*

1. *To reduce a decurted Vessel to a regular form.*

To do this, our Scheme directs to add $\frac{2}{3}$ of the Area of the Circle at the Bung to $\frac{1}{3}$ of the Area of the Circle at the Head, and multiply the Sum by the

the length of the Veſſel, the Product gives the Cubick content.

2. *To find how many Cubick Inches are contained in a Gallon of Beer or Wine.*

This our Scheme doth alſo ſhew, for a Gallon of Beer meaſure, noted with the letter B, doth contain 288 $\frac{3}{4}$ Inches; and a Gallon of Wine Meaſure, noted with W, doth contain 231 Inches, according to the general accompt.

The little graduated Circle through which the Lines are drawn from the vertex of the Scheme, doth ſhew the true quantity of the Angles of Æquilateral Figures, Superficial or Solid, by which they are properly diſtinguiſhed, and may alſo be deſcribed to any proportion required from the quantity of their Angles.

To

To augment or diminish a Circle or Geometrical Square to a duple, triple, quadruple proportion, &c.

ANy Circle or Square figure being given to be augmented to a double proportion, as is the lesser Circle in our upper Hemisphere, described on the Centre of the Scheme: A Diagonal being drawn from the Intersections of the Circumference with the Perpendicular and the Basis on either side, the extent of the same Diagonal terminating in the Centre will describe a Circle in a double proportion to the former: Also a Square made of the Sides of the Diagonal, terminating with the Circumference of that Circle, shall be in a double proportion to the former Square. Thus making the respective Diagonals the Radius of the Circle, the Circles or Squares described by the

ſame, ſhall be augmented in a triple, quadruple, quintuple proportion to the firſt. By a contrary order any Circle or Quadrat may be diminiſhed to any proportion.

Thus much touching the Geodætical Scheme.

THE

THE
DESCRIPTION & USE
OF THE
Gnomonical Instrument.

PART II.

HAving in the former Part shewed the Description and Use of our Geodætical Scheme in the most general Heads, as the same are demonstrated in the Face of the upper Hemisphere, concerning Mensuration; we shall now shew the De-

ſcription and Uſe of our Gnomonical Inſtrument delineated on the Face of the lower Hemiſphere, principally referring to Shadows.

1. *Of the Lines of Right and Reverſed Shadow.*

These Lines are drawn from the loweſt term of the perpendicular Diameter to the extremes of the lateral Diameter of the Scheme in 2 Diagonals, whoſe middle points are equidiſtant from the extremes of the Lines and Centre of the Scheme; both being fitted to the ſame uſe by applying either of their Quadrants to receive the Shadows.

Theſe Lines are graduated from the Limb, according to the proportions of Shadows to the Gnomon or Object, as following,

Altitude of the Sun be		deg. the projected shadow is	times as much as the Gnomon or Object.
deg.	min.		
1	7	50	
2	5	20	
5	42	10	
7	7	8	
9	27	6	
11	18	5	
14	2	4	
18	26	3	
26	34	2	
30	58	5 to 3	
33	41	3 to 2	
36	52	4 to 3	
38	40	5 to 4	
45	00	equal	

Altitude of the Sun be		deg. the projected shadow is	times less than the Gnomon or Object.
deg.	min.		
45	0	equal	
51	20	5 to 4	
53	7	4 to 3	
56	19	3 to 2	
59	2	5 to 3	
63	26	2	
71	34	3	
75	58	4	
78	42	5	
80	33	6	
82	53	8	
84	18	10	
87	10	20	
88	54	50	

The

The Divisions of the Lines being noted with the aforesaid numbers, do shew, That if the Altitude of the Sun be observed by the Quadrant to be 1 deg. 7′ (by the thrid on the Limb) then the shadow of any Gnomon or perpendicular Object is 50 times as much in length as is the Gnomon or Object it self: If the Suns Altitude be 2. 5′ the shadow is 20. If the Altitude be 5. 42′ the shadow is decuple, still exceeding the Gnomon to 45 degrees, at which time the Shadow and Gnomon are equal in length; but as the Altitude of the Sun shall exceed 45 deg. so shall the Gnomon exceed the Shadow according to the proportions on the Lines. These Shadows may be found either by Suns Altitude on the Limb, or by a Gnomon fixt perpendicularly in the Centre of the Scheme.

2. *To take the Altitude of any Object.*

The highest Altitude of the Sun in our

our Horizon, never exceeding 62 deg. the reversed Shadows from thence to 90 the extent of the Lines, will not be applicable (as the rest) in our Latitude; yet, seeing the same proportions do hold in the highest Objects, their perpendicular Altitudes are readily found, by taking the same on the Diameter of the Scheme, and observing the points cut by the thrid, the distance from the Station (and the eye) measured on the Base to the Foot of the Perpendicular,

is either	greater equal lesser	than the height of the Object, if the thrid cut	the right part the middle point the left part	of the Line, by so much as the numbers shew.

Note that these Lines of Shadow are no other than double Tangents, equally divided by their Gnomon, in the points o. 5. 2. oo. 2. 5. o. whose Radius supposed 100, 1000, &c. will render them more useful in Gnomonical Conclusions, than my present time will give me leave to express.

Of

Of the Dial Schemes and Lines.

THese Schemes and Lines (as they are projected) may both serve to Gnomonical Conclusions in the general Scheme, and also to Dialling a part, after various manners, whose principal Uses are as following.

Of the first Dial Scheme.

THe first is described by the three Tangent Lines of the Circle, included within the Triangle; this doth represent an Horozontal Dial, drawn according to the Latitude of 51. 32′ whose Sides are divided into hours, ½ hours, and ¼ hours, distinguished by the Figures, the distance of the shortest prickt Line from the Centre of the

Scheme to the Tangent, extended from the Interſection of the Meridian to the point doth repreſent the the Centre and Stile of the Dial; in which Centre a thrid or ſilk being faſtened, and a little pin of Braſs prepared of the length of the Radius (that is from the general Centre to the inſcribed Circle) with a notch at the end to receive the thrid or ſilk, fix the ſaid pin perpendicularly in the point ☉ next beneath the general Centre, then extending your thrid from the Centre of the Dial over the notch of the pin, being held or faſtened to the Limb, and placing it directly to the Meridian, and parallel to the Horizon, with the point of the Stile to the North Pole; the ſhadow will cut the hour of the day on one of the hour Lines.

To make an Horizontal Dial by the firſt Scheme.

Take the extent of the Lines (in a Parallellogram) from the Scheme, and ſet

ſet off the ſeveral diviſions of each hour, *&c.* then place the Centre in its due point, from whence draw Lines to each Diviſion, and place their Figures as in the Scheme; then let the height of the Stile be equal to the altitude of the pin, at its deſigned diſtance from the Centre.

Of the ſecond Dial Scheme.

THe ſecond Dial Scheme is deſcribed by the Lines of the Triangle, repreſenting a Tangent extended on both Sides the Meridian to the Limb of the Scheme, containing 60 deg. thence continued on the other Sides of the Triangle to the hour of *6*. Theſe Lines do repreſent a Meridian or South-Dial divided into hours, $\frac{1}{2}$ hours, and $\frac{1}{4}$ hours; the diſtance of the longeſt prickt Line from the Centre of the Scheme to the Tangent, extended from the Interſection of the Meridian to the

the uppermost point doth represent the Centre or Stile of the Dial, from whence a thrid being extended over the notch of the pin, fixed in the perpendicular Centre ⊙, beneath the former, and held or fastened in the Limb, it will shew the height of the Stile according to the Complement of our Latitude, *viz.* 38. 28′, and the shadow thereof will give the time of the day in the hour Lines, if the Scheme be placed perpendicular to the Meridian, the Centre of the Gnomon directed to the North Pole.

To make a South Dial by the second Scheme.

Take out the extent of the Lines (in a Parallellogram) from the Scheme, and set off the divisions of each hour, *&c.* the Centre duly placed, draw Lines from thence to each division for the hours, *&c.* let the height of the Stile be equal to the altitude of the pin, at its designed distance from the Centre.

Of

Of the third Dial Scheme.

THe third Scheme is deſcribed by the prickt Lines drawn from the Sine of 45 deg. in the Line of Sines, and 45 deg. in the Limb, and is extended on each ſide the perpendicular Diameter; this is graduated (as are the reſt) from the Limb of the Scheme, allowing 15 deg. to each hour, 7. 30′ to $\frac{1}{2}$ hour, and 3. 45′ to $\frac{1}{4}$ hour: The diſtance of the prickt Line, from the Centre of the Scheme to the Interſection of the Tangent, extended from the point of the Meridian to the middle point doth repreſent the Centre and Stile of the Dial, from whence a thrid being extended over the notch of the pin, fixed in the perpendicular Centre ⊙, next beneath the Centre of the Scheme, it will repreſent the Centre and Stile of the Dial.

To make an Horizontal Dial by the third Scheme.

Take out the extent of the Lines (in a Parallellogram) from the Scheme, and ſet off the diviſions of each (as in the former Planes) and let the height of the Stile be equal to the altitude of the pin at its deſigned diſtance, *&c.*

Of the Horizontal Dial Lines.

THe Horizontal Dial Lines, are thoſe two Lines which are drawn from the lowermoſt point in the Limb of the Scheme (*viz.* at 180 deg.) diagonally to the Latitude of 51. 32′ from the Centre on the Horizontal Line (or parallel Diameter) on each the Meridian. Theſe Lines are compoſed of two Tangents (equal to the Radius) of 45 degrees (generally known by the hour Scale) which being divided

divided into hours, $\frac{1}{2}$ hours, and $\frac{1}{4}$ hours, are uſeful in Dialling after the manner following.

To make an Horizontal Dial by the firſt Hours-Scale.

Firſt draw a ſtreight Line repreſenting the Horizon, then having aſſigned the Centre of your Dial in the middle, take the diſtance from the Centre of the Scheme to the extreme point of the Scale, terminant with the Horizon, and place it from the Centre on the Horizontal Line of your Dial on each ſide ; for the Latitude of the place , let fall a perpendicular from the Centre , and take the extent of the Hour-Scale with one extreme, touching the Horizontal Line in the point of Latitude , let the other touch the perpendicular Line (which doth repreſent the Meridian) then ſetting off the diviſions on this diagonal Line according to the Scale ; Lines drawn from the Centre through each fourth diviſion will give the hours in

in your Dial, and the intermediate points ½ hours, and ¼ hours: The altitude of the Stile is the distance from the Meridian to the farthest prickt Lines from the Centre.

Note that the two Hour-Lines beyond *6*, are equal to those on this side *6*.

Of the Meridian Dial-Lines.

THese are those two other Diagonal Lines terminant in the Horizon nearer to the Centre, which being protracted, the other Extreme will touch the Meridian without the Limb of the Scheme; this Line being laid to the Complement of our Latitude (*viz.* 38. 28′) is fitted to the framing a Meridian or South Dial, as following.

To make a Meridian or South Dial by the second Hour-Scale.

Having drawn an Horizontal Line, and assigned the Centre of the Dial in the middle, take the distance from the Centre of the Scheme to the extreme point of the Scale, terminant with the Horizon, and place it from the Centre on the Horizontal Line of your Dial on each side, for the Complement of the Latitude; then letting fall a perpendicular from the Centre, take the extent of the Scale, with one Extreme touching the Horizon in the point of the Complement of Latitude, let the other touch the perpendicular, from whence a Line being drawn, and the divisions set off according to the Scale; Lines protracted from the Centre through every fourth division will shew the hours, and the other points the $\frac{1}{2}$ and $\frac{1}{4}$ hours. The altitude of the Stile is the distance from the Meridian to the other prickt Line from the Centre.

Also

Alſo Eaſt, Weſt, Æquinoctial or Polar Dials may be drawn from either of the former Schemes or Scales.

Of the Eaſt and Weſt Dials.

THe Eaſt and Weſt Dials are ſuch whoſe Centres are fixed in the Æquinoctial Line, and their Planes behold the due Eaſt or Weſt, theſe being no other than the Tangent of the Æquinoctial Circle graduated to 75 deg. allowing 15 deg. to an hour from the Suns Æquinoctial Motion; the hours of either Dial may be found by the Tangent Line on the Scheme, extended to 120 deg. in the Limb: If from the diviſions of this Tangent, Lines be drawn perpendicularly to the Horizon, the ſame will diſtinguiſh the hours of an Eaſt Dial in the Forenoon, and of a Weſt in the Afternoon, by the pin fixed perpendicularly in the Centre of the Scheme, obſerving to hold the

Inſtru-

Instrument, so as that the Thrid and Plummet may cut the Limb in 38. 28', the Latitude of the Equinoctial; and to use it on either Quadrant, as occasion shall require.

To make an East or West Dial by the Scheme.

First, draw an occult Line through your Plane, in a Centre in the middle describe a Circle representing the Æquinoctial, whose semidiameter may be about $\frac{1}{7}$ of the length of the Plane, then crossing the Centre with a perpendicular Line (which shall represent the hour of *6*) draw two parallel Lines on each side the Circle contiguous with the same, on these Lines (if they be equal with the Tangent in the Scheme) you may set off the divisions of the same Tangent, and draw perpendicular Lines to each of them for the hours.

But if the Radius of the Æquinoctial of your Plane be less than that of the Scheme, with the same Radius de-

ſcribe an occult Circle in the Centre in the Scheme, to which draw a Tangent, you may graduate the hours points by a Thrid or Rule laid on the Centre, and the greater Tangent, or Limb of the Scheme, allowing 15 degr. to an hour, &c.

After this manner may be drawn an Æquinoctial, or South reclining Dial equal to the Complement of the Latitude, *viz.* 38. 28′.

To find the Extent of a Tangent continued above 45 *degrees.*

Seeing the longeſt Tangent Line in our Scheme is extended but to 60 degr. of the Quadrant, the hours of XI and I in the Eaſt and Weſt Dials, and of V and VII in the Æquinoctial, or South recliners fall not within the Circumference, unleſs the Tangent be reverted; as the Extent of the Tangent from 60 to 75 degr. is reverted from the points of 60, to the Centre, being equidiſtant. Therefore to find the Extent of any

Tangent

Tangent above 45. substtact 45. from the degrees of the Tangent whose distance is required, and double the remainder, the Tangent and Secant of this doubled remainder being added, will give the Extent of the Tangent required.

To make an Horizontal Dial by the Triangle near the Centre, representing the Cock of the Dial.

The prickt Lines drawn from the Centre of the Seheme on each side the Meridian to the Latitude of 51 32′, representing the height of the Pole or Stile for an horizontal Dial, crossed perpendicular by another prick Line, do describe two Gnomons or Stiles of Dials, the one serving to an Horizontal, the other to a Meridian or South Dial; each of these figures do describe a Triangle of one Rectangle, and two acute angles; whereof

the	Hypoten. on the horizon.	repre- ſents the Semid. of an	Hori- zontal	dial.
	Baſ. comm. to both Triang.		Æqui- noctial	
	Hypoten. on the Meridian.		Meri- dian.	

Therefore for an Horizontal Dial, let a lateral Line be drawn triple to the length of the Meridian Hypotenuſa, through the Centre in the middle let fall a perpendicular, on which deſcribe a Semicircle at the Radius of the ſaid Hypotenuſa, contiguous with the lateral Line; alſo another ſemicircle beneath, at the Radius of the common baſis, contiguous with the ſaid Line; this ſemicircle divide into 12 equal parts, or graduate the ſame from the Scheme (by an occult Circle) then laying a Ruler on the Centre, and every diviſion in the ſemicircle, make points on the contingent Line, from which points, and the Centre of the greater ſemicircle, the Hour-lines may be drawn, and alſo the $\frac{1}{2}$ and $\frac{1}{4}$ hours, if you divide the ſpace between the Lines of the leſſer ſemicircle into 4 equal parts, &c. the ſtile muſt be equal to the horizontal perpendicular. *To*

take the Figure of the Gnomon, at a convenient diſtance from the Centre, and laying the Hypotenuſa on the Horizon, and the Angle at the perpendicular to touch the Centre; draw a Line through the Baſis and all the parallels of the Signs, which ſhall repreſent the Meridian or Twelve a clock in your Dial; the extent from the point where this Line interſecteth the Æquinoctial, and the Angle at the Baſe of the Gnomon placed upon your Dial (being already drawn) from the Centre on the Meridian, ſhall be the true diſtance of the Æquinoctial, both from the Gnomonical point and the Centre of the Dial, through which point a Line is to be drawn parallel to to the Horizon: Then from the Centre of your Dial, take the extents of the interſections of the ſeveral hours with the Æquinoctial Line, and place them from the Angle at the Baſis of your Gnomon to the Æquinoct. parallel as in the Scheme, which being protracted ſhall cut the parallels; the diſtance of theſe

interſections from their common Angle: taken out of the Scheme, and placed from the Centre of the Dial to their reſpective Honr-Lines, ſhall give the parallels or diſtance of all the Signs, which may be deſcribed by Lines drawn through the points, and noted with their reſpective Characters. The like may be done in a Meridian Dial, by placing the Gnomon as formerly, and extending the Lines, *&c.*

To place the parallels of the length of the Day on a Horizontal or Meridian Dial.

For placing the Parallels of the length of the day, you muſt deſcribe the proportional parallels of the Suns Declination, according to the Table following.

Theſe parallels being placed in the Scheme, according to their reſpective de grees, you may proceed in all things as before, to place their diſtances on the hour lines in you Dial, which being duly obſerved, you will thereby gain the length of the Night by ſubſtracting the length of the Day from 24, the remainder gives the length of the Night.

len. day.	Sun Declin.	len. day.
12	00 00	12
11	5 43	13
10	11 14	14
9	16 22	15
8	20 59	16

To place the Planetary Hours in an Horizontal or Meridian Dial.

The Planetary Hours which are ſometimes diſtinguiſhed by unequal or Artificial Hours, are found by dividi ng the Day, from Sun-ſitting to Sun-riſing, whethea Winter or Summer, into 12 equal parts, alſo the Nights into as many; the times contained in any ſuch part is to be accounted an Hour, which

in.

in the Summer are greater, in the Winter leſſer then our natural Hours. To place theſe Hours in a Dial, you are to obſerve the parallels of 15 and 9, being 3 Hours diſtance from the Æquator on each ſide, and therefore the moſt proper. The firſt Hour is to be drawn through 5 Hours 45 min. in the parallel of 15. and 8 hours 15 min. of the parallel of 9. The ſecond hour is to be drawn through 7 hours 0′ in the parallel of 15 and 9 hours 0′ in the parallel of 9. Thus may you proceed to draw the 12 Planetary hours on the Dial, by adding 1 hour 15 min. till you come to 12 hours, then begining at 1 hour 15 min. for the *7th.* hour, *&c.*

To place the Azimuths in an Horizontal, or Meridian Dial.

Take the diſtance of the perpendicular of your gnomon, out of the Scheme, (whether it be of an Horizontal, or Meridian Dial,) and with the ſame (as the Radius) deſcribe a Semicircle, which devide into 16 equal parts; a Tangent being drawn to the ſaid Semicircle, let Lines be protracted from the Centre through each Diviſion of the Semicircle to the Tangent: Note where the ſame do touch; for thoſe diſtances drawn perpendicularly to the 2 Tropicks of your Dial, (whoſe Gnomonical Point at the Angle of the perpendicular, ſhall be equal to the Radius of this Semicircle) will deſcribe the Azimuth Lines diſtance from each other 11 deg. 15 min. ſhewing the Points of the Compaſs: By the ſame Rule, you may deſcribe Aſtronomical Azimuths of 5, 10, or more or leſs Degrees, as occaſion ſhall ſerve.

To place the Almicanters in an Horizontal or Meridian Dial.

Theſe Parallels being Circles of Altitude, will be Conical Sections in the plane which may be deſcribed through their Interſections with the Azimuths, as were the Parallels of declination through their Interſections with the hour Lines.

Note

Note, that the Months of the Year, (known by the Letters) are placed in the Column anſwering to the reſpective Signs, which ſerves not onely to diſtinguiſh the Months and Signs of each Month which the Sun paſſeth in his Zodiacal Revolution; but alſo ſheweth his Declination from the Æquator, the increaſe and decreaſe of the day, riſing and ſetting, and other Aſtronomical Concluſions.

The other Lines, *viz.* the Line of Chords drawn Diagonally in the leſſer Parallellogram (ſerving principally for transferring of Angles from the Dial Shemes to planes.) The Line of Sines from the Centre to the Circumference on the right hand above the Diameter. The Line of Equal Parts beneath the ſame. The Line of Tangents to 45 deg. from the Centre to the Circumference, on the Left-hand above the Diameter. The Line of Proportions (or Numbers) beneath the ſame. The uſes of which being general, and generally known, (as having been written on by divers Authors in almoſt all Mathematical Tracts) I ſhall refer to the Ingenious Practitioner and the Authors upon the ſame: Together with the other uſes of our Scheme, which leiſure nor opportunity would permit to remmerate or mention at the preſent. *Vale*

FINIS.